Explanation of sheet 75, West Aberdeenshi

Memoirs of the Geological Survey,

SCOTLAND.

EXPLANATION OF SHEET 75

WEST ABERDEENSHIRE, BANFFSHIRE, PARTS OF ELGIN AND INVERNESS.

By LIONEL W. HINXMAN, B.A.,
With Petrological Notes by J. J. H. TEALL, M.A., F.R.S.

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PREFACE.

SHEET 75 of the Geological Survey Map of Scotland embraces that region of the Highlands which stretches northward from the slopes of the Cairngorm Mountains, Glen Gairn and Culbleen, to Strathspey at Grantown, the valley of the Avon below Glen Livet, and the course of the Blackwater at Blackwater Lodge. The district of which it represents the geology includes a large development of the characteristic schistose rocks of the north-eastern Highlands, disrupted on the south by the Cairngorm granite, and partially overlain with outliers of Old Red Sandstone.

Some portions of this tract of country have been visited and described by previous geologists, whose writings are cited on p. 48. The Map has been entirely surveyed by Mr Lionel Hinxman, B.A., who has also prepared the following Explanatory Memoir. The petrographical descriptions have been supplied by Mr J. J. H. Teall, F.R.S. Some of these are embodied in the account of the general geological structure of the district, and the distribution of the different rocks. But Mr Teall has also furnished a special section on some of the more notable features of the petrography (p. 35), together with a list and brief diagnosis of the rocks which have been collected and microscopically examined (p. 43).

ARCH. GEIKIE,
Director-General.

GEOLOGICAL SURVEY OFFICE,
28 JERMYN STREET, LONDON,
15th September 1896.

EXPLANATION OF SHEET 75.

I. AREA EMBRACED IN THE MAP.

This sheet of the Geological Survey of Scotland represents an area of 432 square miles, including a considerable part of West Aberdeenshire, the whole of the southern and highland portion of the county of Banff, and small portions of the eastern limits of Elgin and Inverness. The village of Tomiutoul may be taken as the approximate centre of the district shown in the Map, which extends from Cromdale in Strathspey eastwards to the Cabrach in the north, and on the south from Culblean Hill on Deeside westwards to Beinn á Chaoruinn on the watershed of the Cairngorm Mountains.

II. PHYSICAL FEATURES.

Essentially a mountainous region, one-fourth at least of the area under consideration rises to a height of 2000 feet above sea level, while more than 15 square miles of ground reach an elevation of upwards of 3000 feet. The eastern portion of the great high-level plane of denudation, out of which have been carved the Cairngorm Mountains, extends for 8 miles along the southern margin of the Map, with a mean elevation of over 3250 feet. To a lower plane of denudation, having a mean summit-elevation of about 2400 feet, belongs the wide extent of hilly, rather than mountainous country that occupies the larger part of the area. Erosion has here been carried much further than in the Cairngorm range, and little of the original plateau remains.

The most important ranges of the secondary hill-system are the nearly continuous ridge of the Cromdale Hills between the Avon and the Spey; and the line of smooth, rounded summits, separated by shallow cols, that runs in a N.N.E. direction from the flanks of Ben Avon to the Cabrach along the county march between Banff and Aberdeen.

Another well-defined range, starting from the same point, extends eastwards from Loch Builg and forms the watershed between the Don and the Dee, culminating in the conspicuous hill of Morven in the south-east corner of the Map.

In addition to these are the less easily defined masses of high ground north of Glen Livet—the southern spurs of the Corryhabbie Hills—and along the eastern margin of the Sheet round the Buck of the Cabrach.

River Systems.—Portions of no less than four important river basins are found within this area. That of the Don, with its tributaries the Ernan, Nochty, Bucket, Kindy, Conrie, and Carvie Waters, occupies the greater part of the eastern half of the Sheet. A small area in the north-east, including the basin of the Upper Cabrach, is drained by the head waters of the Deveron, while in the south, the Gairn and other smaller streams carry the water falling on the southern slopes of Ben Avon and the Morven range into the Dee.

Although neither the source nor the mouth of the Avon fall within the Map, it includes nearly the whole of the course of this, the largest tributary of the Spey, which, with its tributaries the Livet, Conglass, Lochy, Ailnack, and many other smaller streams, drains almost the whole of the highland part of the county of Banff.

The western slopes of the Cromdale Hills and the high ground enclosing Glen Dorback and the Braes of Abernethy belong to the basin of the Spey, a small portion of whose course crosses the extreme north-west corner of the Map.

The streams throughout the more hilly portions of the area are generally torrential in character, and preserve a straight course through narrow trench-like valleys with little alluvial deposit. The River Avon and its tributary the Caiplich have, however, in the highest portion of their course, nearly reached the base level of erosion, and flow for some distance with a gentle winding course through alluvial stretches of some breadth. These may possibly also represent the beds of former lochs, whose waters have been gradually silted up or drained by the deepening of the rock gorge below.

There is evidence to show that the junction of the Conglass Water with the River Avon was, at a comparatively recent period, immediately north of the village of Tomintoul, and nearly 3 miles above its present position. The peat moss known as the Feith an Dobhrain, that lies in the hollow between the foot of the village and the wood of Lag na Culaige, occupies the channel by which the burn joined the Avon at a time when the latter ran at the level indicated by the high terrace at Upper Cults. In the eastern part of the area under consideration the streams are less impetuous, and the Don especially has all the characteristics of a lowland river, pursuing a sinuous course through alluvial valleys often more than half a mile in breadth. The wide tract of alluvium that lies between the mouth of the Ernan and Pooldhulie Bridge, taken in connection with the evidence of a lowered rock barrier at Pooldhulie, suggests the former existence of a loch of considerable extent between those two points.

Lakes.—Besides a few small mountain tarns in the corries of the Cairngorms, the only piece of water in the Map is Loch Builg, a small loch, ¾ mile in length, that lies at the foot of Ben Avon on the watershed between the Gairn and the Avon. This loch has the peculiarity of draining at both ends. Under normal conditions there is an outflow to the north by a small stream which falls into the Builg Burn, a tributary of the Avon. A few weeks of dry weather are however sufficient to lower the loch below the level of this outlet; and the water can then only escape by percolation through the gravel moraines that hem in the southern end of the loch, whence it finds its way through a series of small lochans at different levels into the River Gairn.

III. FORMATIONS AND GROUPS OF ROCK.

Aqueous.	Recent.	Basin-Peat, Hill-Peat.
		River and Lake Alluvium.
	Glacial.	Moraines.
		Erratic Blocks.
		Sands and Gravels.
		Boulder Clay.
		Striated Rock Surfaces.
	Lower Old Red Sandstone.	Sandstone and Conglomerate.

Metamorphic.	Banffshire Series.	Quartzite.
		Black Schist and Limestone.
		Clay Slates and Phyllites.
		Mica Schist, Andalusite Schist, Kyanite Schist.
	Cromdale Hills Series.	
Intrusive—Igneous.	Pre-foliation.	Foliated Granite.
		Mica-diorite, Epidiorite, and Hornblende-Schist.
		Gabbro.
		Serpentine.
	Post-foliation.	Cairngorm Granite.
		Quartz-Porphyry, and Felsite.
		Augite-diorite.

IV. General Geological Structure of the Area.

The greater part of the ground represented by this Map is occupied by the Metamorphic Rocks of the Central Highlands, the various members of which will be described later on in detail. The Lower Old Red Sandstone occurs as two outliers of unequal size, resting unconformably upon the older rocks. The largest of these occupies about 14 square miles of ground round Tomintoul; the other, a small patch, lies along the course of the Deveron in the Upper Cabrach basin. The great mass of the igneous rocks belongs to two distinct intrusions, differing both in age and character. The newer or "Cairngorm" Granite forms the high ground along the southern margin of the Map, extending from the mountains at the head of Glen Avon, with one or two breaks, to Culblean Hill. The older basic intrusion traverses the eastern part of the Sheet from north to south in a belt varying from one to six miles in breadth. Being of the nature of a sill, its boundary lines are approximately parallel to the strike of the schists into which it has been intruded.

On looking at the various hands of colour that represent the different members of the metamorphic series on the Map, the eye will be at once struck by the uniform bend to the eastward that takes place along a line running east and west nearly through the centre of the Sheet. Starting from the edge of the granite area in the south, the general strike—neglecting minor flexures—is N.N.W., but at the point referred to above, it swings round to the N.N.E., and henceforward preserves a general north-easterly direction for nearly 40 miles to the coast of Banffshire. Another noticeable point is the repetition of zones of the same colour. This is due to the fact that the rocks have been thrown into a series of complex isoclinal folds, with a general steady dip to the east. The same zone or parts of a zone may in this way be repeated an indefinite number of times, and a comparatively small thickness of strata made to occupy a disproportionately large extent of ground.

This same complexity of structure, and the absence of any recognisable base in the quartzites of the area, have made it impossible to determine with any certainty the order of succession among the different zones of the metamorphic rocks. From evidence obtained elsewhere along the line of outcrop to the north and south, it is, however, probable that the quartzite is the highest member of the group, and immediately overlies the phyllite, black schist, and limestone zone.

There is throughout the region a remarkable absence of normal faults of any magnitude, though it is probable that there are many minor dislocations concealed by superficial deposits.

Quartzite.

The system of isoclinal folding that has determined the arrangement of the metamorphic rocks in this area has caused what is possibly but a single zone of quartzite to be repeated in a series of parallel bands of varying breadth stretching across the Map; or in isolated lenticular or boat-shaped masses. From the harder nature of this rock, as compared to the schist and slates with which it is associated, it usually forms the higher summits and ridges, and the numerous *Geal Carns* (White Cairns) seen scattered over the Map indicate where the weathered quartzite debris, pure white in colour, strews the bare hill-tops.

In general character the quartzite may be described as a fine-grained homogenous crystalline-granular rock, internally yellowish to pinkish in colour, but weathering snow-white. The texture of the rock is often entirely or in great part granulitic, but in various localities the original clastic grains can still be distinctly recognised, while there are in addition bands of pebbly grit of local occurrence that show the undoubted sedimentary origin of the rock. Felspar and white sericitic micas are present in varying amount, the latter only where the rock is schistose or shows signs of mechanical deformation.

The first important development of the quartzite in the east forms a belt that extends northwards from the edge of the epidiorite mass in Glen Finzie, crosses the Don at Garchory, and forming the ridge of high ground that is trenched by the upper waters of the Ernan, Nochty, and Bucket passes out round the end of a fold on the slopes of the hills at the southern boundary of the Blackwater Forest.

The rock throughout this zone is very uniform in character—massive and granulitic—with the bedding planes ill-defined. The dip where it can be observed indicates a general strike varying from N.N.W. to north by east. It should be noted that the comparative regularity of the boundaries of this and of the other zones of the metamorphic area, as represented on the Map, are generalisations rendered necessary by the paucity of sections and covered nature of the ground. It is highly probable that in such a region of complex folding, the actual outcrops, if it were possible to trace them in detail, would be found to be of an extremely irregular character, such as that indicated on the north side of the Little Glen Burn in Glen Nochty, and on the west side of Carn Leac Saidheir in Corgarff.

The next band of quartzite to the west enters the Sheet on the north between Glen Fiddich and the Blackwater, and forms the high range of Cook's Cairn, Cairn na Bruar, and Cairn na Glascoill. It continues in an attenuated form through the hills at the head of Glen Livet, and crossing the Conglass Water above Blair-na-marrow broadens into a boat-shaped mass of irregular outline occupying the high ground along the Banffshire county march immediately to the west of General Wade's military road.

The sedimentary origin of the quartzite in this band is more distinctly apparent than in that first described. On Cook's Cairn and Cairn na Glascoill lenticular bands of coarse grit are intercalated with ordinary fine-grained rock, and at the last named locality pebbles of clear and milky quartz occur up to nearly half an inch in length. The coarser bands are sometimes very felspathic, and the colouring of the felspar often gives a pinkish tinge to the whole rock. On the hill side immediately above the Conglass Water, half a mile south of the Iron Mine, there is a good exposure of the rock, which at this point passes into a grit sometimes extremely coarse, with abundant rounded fragments of "blue" or semi-opalescent quartz. It also contains aggregates of sericitic mica, a

small amount of felspar, and magnetite plentifully disseminated throughout the rock in detached grains (6063).*

Another large area of quartzite occurs on the west side of Glen Fiddich. It occupies the high ground of the Corryhabbie range, and extends across the valleys of the Livet and Crombie Waters to Knockandhu, where it is overlaid by the northern extremity of the Old Red Sandstone outlier. The weathered debris that strews the summits of Corryhabbie is somewhat felspathic, and towards the north has a slightly sheared appearance. A good section is exposed in the deep gully cut by the Allt na Saobhaidhe on the west side of Glen Suie. At the head of this burn the rock is massive and granulitic, but lower down the divisional planes become more distinct, with a steady dip to the south-east, and the rock gradually passes into a felspathic quartz-schist difficult to separate from the grey phyllitic mica-schist that comes on below.

Fragments of gritty quartzite cover the top and southern slopes of Carn Muldonich, and the rock is seen in place at Allanreid and in the Allt na Bae, where it contains a few seams of silvery garnetiferous mica-schist. Carn na h' Iolaire and the conspicuous rounded hill of the Bochel, on either side of the Crombie Water, are also composed of quartzite, and the same band, brought round by a large fold, reappears on the further side of the Old Red Sandstone area, and forms the high ridge of Carn Ellick and Carn Daimh. The summits of these hills are strewn with angular blocks of white and pinkish quartzite, but the rock is only visible in place at the head of the Allt á Chor, in close conjunction with the Torulian limestone.

Small isolated masses of quartzite occupy the summits of Carn Liath and other hill-tops in the lower part of Glen Livet; but the next outlier of importance extends from Tom a' Chor, north of Glen Chabet, across the Conglass to Campdalemore at the foot of Cnoc Lochy. At this point the quartzite is cut off by a fault which leaves the course of the Avon at the bend made by that stream below Upper Cults, and striking N.N.W. over the hill joins the river valley again at the point where the road comes down to the stream, half a mile below the bridge. A nearly parallel branch of this fault coincides with the course of the river at Urlarmore, and at the Bridge of Avon the quartzite that forms the irregular outlier on Tomblireac and Meall na Caorach can be seen brecciated and faulted against the limestone.

In a small burn that falls into the Avon opposite the farm of Delavorar, 2 miles south of Tomintoul, the Old Red Conglomerate overlies a band of quartzite which extends in a south-west direction over Liath Bheinn and Creag Mheann to the head of the Don. The rock is exposed in the Allt na Kyle and the Muckle Fergie Burn. It is a massive crystalline pinkish quartzite, much jointed and shattered in places, contains a good deal of pink felspar, and is often coarse-grained and gritty in texture. In the fine section seen in the Muckle Fergie Burn, a short distance above the point where the stream crosses the road, two or three lenticular bands of calcareous quartz-hornblende schist, containing large pebbles, occur at the base of the quartzite. This rock closely resembles the "Boulder-bed" found at the base of the quartzite in Perthshire and Argyle. The matrix is a dark schist containing large ragged individuals of green hornblende, elongated as in an actinolite, set in a granulitic aggregate of quartz and calcite, with iron ores as an accessory. The schist contains fragments of dolomitic limestone, sometimes large and irregular in shape, sometimes drawn out into lenticles; and also rounded

* The numbers in brackets refer to the rock slides in the collection of the Survey.

pebbles of a reddish granite with blue quartz. The rock probably originated as a calcareous muddy sediment containing scattered pebbles.

The most westerly development of the quartzite occupies the greater part of the peat-covered hills between Glen Dorback and Glen Brown, where it underlies the Old Red Sandstone on the west side of the Burn of Brown. Continuing south-eastwards it crosses the Water of Ailnack and extends over Carn Ruadhbhruaich and Geal Charn to the Avon at Daluisge, thence thinning out rapidly to the south along the Fail an Turc and the foot of the Eilead.

The quartzite along this line shows much greater movement than elsewhere in the Sheet. In the gorge cut by the Allt Dearcaige, a tributary of the Ailnack, the rocks are for the most part thoroughly sheared, and often pass into fissile quartzo-felspathic schist. Similar phenomena are seen in the Ailnack gorge, where a band of black schist and limestone is folded in with the quartzite. In both sections there are many lines of fracture, forming small gullies, along which the rock is intensely shattered.

On the hills that rise above the Avon at Daluisge the quartzite is also much sheared and drawn out, but the original particles, especially where the rock is coarse-grained or gritty, are still recognisable. South of Daluisge, a sharp isoclinal fold causes the quartzite to dip beneath the limestone of the Eilead, and the line of junction is shifted several times by a succession of small cross faults. The effect of movement in the production of "rod-" and "mullion-structure" is particularly well seen here at the roadside, and in the Allt Nathrach on the other side of the river (Fig. 1).

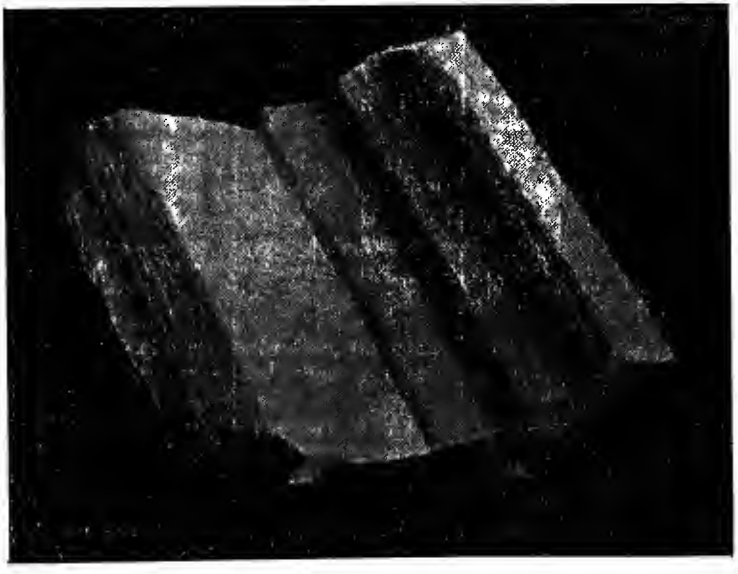

FIG. 1.—"Mullion-structure" in sheared quartzite.
Daluisge, Strathavon.

"Black Schists and Slates."

The "Black Schists" are best developed in Glen Livet and Strathavon, where they form a belt of varying breadth that extends nearly across the Map from Glen Tervie to Loch Builg. They may be generally described as dark, carbonaceous, garnetiferous, mica-schists or slates. The amount of carbonaceous matter varies much in quantity; it is most abundant in the western and central portions of the belt, and decreases towards the east and south-east. This decrease takes place in an irregular manner and often along the strike of the beds, the dark slates or schists being found to pass into grey phyllites or clay-slates by the gradual disappearance of the carbonaceous material along the line of outcrop. The original bedding-planes, as distinct from the foliation, are generally still recognisable in lines of different sedimentation; while a third set of divisional-planes, arranged at a considerable angle with the foliation, can often be detected. These planes indicate strain-slip-cleavage (*ausweichungsclivage*), and produce the minutely corrugated or puckered structure which is so constant a feature of these rocks, though less readily recognisable in the more slaty varieties.

The black schists are generally more or less garnetiferous, but this mineral is most abundantly developed in the south, as they approach the granite areas of Glen Gairn. Large perfect crystals of andalusite and staurolite begin to make their appearance in the schists north of Glen Tervie, in the neighbourhood of the Ben Rinnes granite mass. The relations of these crystals to the planes of *ausweichungsclivage* show that the minerals have been developed, probably by thermo-metamorphism, subsequently to the movements that produced the puckering.

A splendid section of these rocks is afforded by the deep gorge of the Ailnack, south of Tomintoul, which for 2 miles cuts nearly at right angles across the strike of the schists and their associated limestones. In the high rocky walls of this chasm the complex folding, and the relations of these rocks to one another and to the overlying Old Red Sandstone Conglomerate, can be studied to great advantage.

Typical specimens from this section show the following characters under the microscope (3435–6). The matrix is composed of minute grains of quartz, scales of white mica, and grains and clots of an opaque substance which is largely carbonaceous. The larger constituents are brown mica, garnet, and chloritoid (?). The opaque grains run through the substance of the mica without any change of direction; while the garnet forms conspicuous knots, and the lines of inclusions are bent aside where they come near the latter. The mineral referred to as chloritoid is pale in colour. It does not show any definite orientation, but the flat surfaces of the plates are often inclined at a high angle to the direction of the streams of granules. The central portions of the crystals are full of these minute crystals, and there is no marked bending aside of the streams as they encounter the mineral. The puckering of the schist may often be observed in the arrangement of the inclusions. There can be no doubt, therefore, that this mineral was developed after the schistosity and puckering. The bands of dark calcareous schist intercalated with the ordinary black schist along this section are composed of calcite, quartz, and white mica, through which run the usual streams of black carbonaceous granules. There are also large irregular plates of brown mica, in which the lines of granules are often arranged nearly at right angles to those in the matrix; a fact which points to movement subsequent to the development of that mineral.

A good section of these rocks is also to be seen along the Muckle Fergie Burn, east of the Liath Bheinn quartzite. They can here be followed for more than a mile across the strike; and show the rapid folding at high angles and gradual passage of the typical black schists into grey slates and garnetiferous mica-schists.

Other localities where this series is well exposed are Tomnavoulin (3816) and Slateford in Glen Livet; and along the valley course of the Avon from Gaulrig to Lagganauld. In Glen Livet they are less highly metamorphosed and pass into fine-grained black slates containing a good deal of magnetic pyrites, and a biaxial mineral giving bright lustre on cleavage faces and apparently of prismatic form. The exact nature of this mineral has not been determined, but it has evidently been developed since the schistosity. About Inchrory and Lagganauld the schists are highly garnetiferous and finely puckered, but contain less graphitic matter than further to the north.

A lenticular band of black slate, passing on either side into grey mica-slate, has been mapped out at the head of the Ladder Burn, between Letterach and the Dun Muir. A good section of these highly ferruginous, dark, banded, and cleaved slates is seen in the Allt Clach, a small tributary on the north side of the Ladder Burn.

A well-defined and continuous belt of black slate and schist will be noticed extending across the Map from Blackwater Lodge to the head of Glen Conrie, south of the Don, where it passes beneath the great diorite sill. The average breadth of the outcrop is about 500 yards, but in Glen Bucket reaches nearly half a mile. The section seen in the stream at this point shows a passage from slaty phyllites eastwards through black slates and slaty schists with small knots and garnets, into corrugated garnetiferous mica-schists. Passing southwards through Glen Nochty, where a fissile, cleaved black slate is exposed in the Quillichaw Burn at Toldhuquhill, the belt crosses the Ernan Water and makes a sudden bend round a synclinal fold on Carn Mòr. On the north side of this fold and also near Tolduquhill, thin lenticular bands of schistose blue limestone are associated with the slates.

The exact position of the outcrop southwards from Skellater and across the Don is uncertain, owing to the heavy covering of drift; but the slates are seen again in the burn at Boggach, and a continuous section is exposed in the head of the Conrie Water above Lynemore. The rock in this section is more metamorphosed, and becomes a corrugated, black, knotted schist, with which are associated several thin sills of epidiorite and felsite, some of which show distinct foliation.

Limestone.

The limestones are almost entirely confined to the area occupied by the black schists, with which they are closely associated. The irregularity of outline and variation in breadth of the different limestone outcrops may be attributed partly to the original deposition of the rock in lenticular beds, and partly to the intense over-folding to which the rocks have been subjected. Thus a band, normally of no great thickness, may by repetition have been made to occupy a wide extent of ground. The sudden increase in breadth of outcrop is sometimes also visibly due to small thrusts driving the limestone upon itself. The intricate system of over-folding and thrusting that obtains amongst these rocks can be well studied on the weathered faces of the crags about Inchrory, where the beds are seen in section. On such a face the general structure of the

country is often completely represented in miniature over a few square feet of rock.

The largest and most continuous belt of limestone extends from a point a little to the north of Torulian in Glen Chabet across Glen Conglass to the Avon at Urlarmore, where it forms a band nearly a mile in breadth, and is quarried along the roadside at Craig Chailcheach (*Halkie*). South of this point it is interrupted by the Old Red Sandstone outlier, but appears again in the Ailnack gorge, where its intercalation and folding with the black schists is beautifully exposed. The limestone is next seen in thin

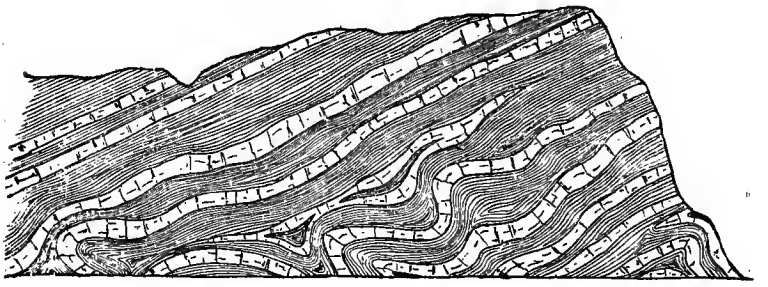

Fig. 2.—Folded Black Schist and Limestone, Ailnack Gorge, Tomintoul.

lenticular bands amongst the schists along the lower slopes of Liath Bheinn in Strathavon, and gradually increasing in breadth forms the fine range of cliffs that flank the glen on the east, from the Foal's Craig to Inchrory, and are continued up Glen Builg nearly to the loch. Between the foot of Loch Builg and the Meikle Geal Charn the outcrop attains its maximum breadth of at least a mile.

An isolated area of limestone of some extent and very irregular outline is found in the Braes of Glen Livet, extending westwards from the Crombie Water at Chapeltown to the Old Red Sandstone boundary. A third and more continuous band enters the Map on the north at the head of Glen Fiddich, and is continued down Glen Suie to the Kymah Burn, where it is interrupted by the granite, but reappears south of the Bly Water and extends across by Corry and Auchavaich to Scalan, whence it thins out to the south-west, appearing again in small isolated lenticular patches near Lynavoir in Glen Conglass.

The limestones throughout the region referred to above are very uniform in character; usually highly crystalline, and light to dark grey in colour. In Glen Chabet and Glen Conglass a white dolomitic variety occurs, weathering with a rusty-brown or yellow crust. At several localities in Glen Livet there are bands of black, sandy limestone intercalated with the purer and more crystalline varieties. The original bedding planes are generally recognisable, and are often intensely crumpled and folded; while additional planes of schistosity have been developed in several places. The limestones in the upper part of Glen Builg are filled with thin veins and cores of chert and quartz. These have segregated out along the divisional planes, and serve to emphasise the intense crumpling to which the rocks in this area have been subjected. In the immediate neighbourhood of the Cairngorm granite the rock is generally much altered; marmarosis of the purer portions and the production of tremolite and malacolite-rock from the impure limestones being the common phenomena of contact metamorphism; together with

the development of garnets (cinnamon-stone and grossular), idocrase, and other contact minerals.

A lenticular band of limestone in the gneiss near the granite boundary at Rinloan, in Glen Gairn, is a well-known locality for rare and beautiful mineral specimens, first made known by Prof. M. F. Heddle.

On the west side of Glen Builg pink calcite is abundantly developed in strings and rounded masses. This mineral also occurs in a brecciated vein-rock along a line of fault that crosses the three small streams known as the Tri Caochan, that fall into the Avon 3 miles north of Inchrory. Fluor-spar is associated with the calcite in this locality, and fine specimens, both of the green and purple varieties, can be obtained.

Several outcrops of limestone will be noticed in the Corgarff district on both sides of the River Don. Some of these show a marked departure from the normal line of strike; their trend, together with that of the contiguous schists, being approximately parallel to the granite boundary on the south; and it seems probable that the disturbance or upheaval produced by the granite intrusion has been the cause of this deviation.

One of these bands has been quarried at Luib and on the slopes of Carn Iain above Alltnaciste. In both these localities the rock, a crystalline grey limestone with sandy layers, is much crumpled and is traversed by a thin sill of epidiorite, close to which the limestone has a hardened and baked appearance, while the impure sandy portions are converted into quartzite. Another belt of similar rock crosses the Leachd Road and the Loinherry Burn, where it sends off a powerful spring known as Tobar Fuar—the cold spring. Between Corriehoul and Tornahaish two other bands cross the River Don. One of these is quarried on Tornahaish Hill, where it is a rock similar to that described above, also associated with thin sills of diorite, and in addition traversed by a red felsite dyke.

Numerous thin bands of a fine-grained schistose black limestone are intercalated with the slates and epidiorite sills of Allt Slochd Chaimbeil and Glen Ernan; where the rapid alternations seen in the section are probably due to over-folding.

A broader band of grey very crystalline limestone, much veined with calcite, has been largely quarried at Corriemore, between Glen Bucket and Glen Nochty. Other smaller limestone outcrops are found in several parts of the Sheet, amongst which reference may be made to the inclusion in the diorite at Tornahaish, and on Mammie Hill in Glen Gairn.

Mica-Schists, Clay-Slates, and Phyllites.

The mica-schists, clay-slates, and phyllites of the central portion of the Sheet form so intimately connected a series and pass so insensibly from one into the other under varying degrees of metamorphism, that it has been found very difficult to separate them on the ground. Typical hand specimens of each class of rock can easily enough be obtained; but to assign even approximate limits to each variety, in a country where wide stretches of ground entirely obscured by thick peat and drift intervene between the stream-sections, is an unsatisfactory and almost impossible task.

The phyllites are well developed in the Blackwater Forest area, on either side of the black slate band; and the western tributaries and head waters of the Blackwater give good sections of these grey, fissile, and slaty phyllites, with which are intercalated thin seams of quartzite and quartz-schist. The divisional planes are vertical or nearly so; and the strike—at first N.N.E.—swings round to north by west south of Thiefsbush

Hill. A lenticular band of phyllite also occurs folded in with the quartzite along the slopes of Cook's Cairn and Cairn na Bruar. A similar series of rocks, with the addition of numerous thin sills of porphyritic epidiorite, is exposed in the Coulins Burn and its tributaries above Glen Bucket Lodge. South of the Moss Hill the trend again changes to north-east and the rocks gradually assume a more schistose character. For some distance south of Glen Ernan there are few satisfactory exposures, but across the Don at Boggach, and in the stream on the west side of the Socach Wood, a complete passage into typical mica-schist will be seen to have taken place.

The deep hollow that separates the quartzite ridges of Carn Bruar and Corryhabbie has been excavated in a band of soft phyllite associated with the Glen Suie limestone. A good section of these phyllites is seen in the Fore Burn of Glen Suie. They are here grey and slaty, with incipient puckering; but to the north of the watershed pass—either by folding or by the gradual introduction of carbonaceous material—into corrugated black slates. At Knockan on the Kymah Burn, close to the northern boundary of the Glen Livet granite, they have been altered by contact-metamorphism into a banded, flaggy biotite-schist, in which the structure of the quartz and felspar aggregate is granulitic, and the biotite probably secondary. A similar contact-rock occurs at Nethertown, 2½ miles further down the Livet Water (4853).

Clay slates and phyllites compose the greater part of the range of smooth, rounded hills that divides Glen Livet from Strathdon. On their eastern slopes the rocks are much less altered than elsewhere in this region, and the deep glens cut by the head streams of the Nochty and Ernan Waters give continuous sections of soft, very felspathic clay slates and shaly sandstones, in which sericitic mica is the only secondary mineral present, with thin seams of more quartzose material (2967–8). The clay slates are generally banded with dark stripes of graphitic material which forms a sort of network round the quartz grains; and these rocks may represent an early stage in the history of the graphitic schists further to the west.

South of Glen Ernan the metamorphism is more pronounced, and in the Corgarff district the rocks show cleavage and incipient puckering. The cleavage-planes are often inclined at a considerable angle to the planes of bedding, the latter being indicated by alternations of fine and coarse sediment. These cleaved phyllites and hydro-mica-schists are well seen at Tornahaish, the Craigs of Ordachoy, Allt a Choillich south of Cockbridge, and along the Milltown Burn, where they pass northwards into corrugated black schists. In many localities they contain garnets, also knots and concretions of a soft chloritic mineral; and in the Tornahaish Burn the surfaces of the slates are full of minute cavities produced by the weathering-out of small crystals of chiastolite.

Kyanite in fine rod-shaped crystals occurs in a silvery mica-schist with calcareous bands on the west bank of the Livet Water near Tombreakachie.

A considerable area of mica-schist occupies the ground along the eastern border of the Map south of the Upper Cabrach. It is somewhat different from and more homogeneous than the schistose rocks further to the west, and its relations to that series have not yet been clearly determined. In the northern part of this area, where good sections are visible along the courses of the Allt Deveron and the Kindy Burn, the schist is thoroughly granulitic, and usually contains two micas—biotite predominating—quartz and felspar. The folia are often much crumpled, and the rock is sometimes very coarse-grained, and gneissose in character. Segregation-veins and strings of quartz, sometimes glassy-clear, are frequent. Intercalated with

the mica-schist there are many lenticular bands of quartz-schist and quartzite. These are usually only a few feet in thickness, but a belt of quartzite, several hundred yards in breadth, is interfolded with the schists across the Sand Hill and the head waters of the Allt Deveron; where good sections showing the sharp folding of the quartzite can be seen along the small tributary burn of Alunsheal.

Along the watershed between Glen Kindie and Glen Bucket the schist passes into a gnarled granitoid gneiss containing large garnets. At Buchaam Bridge and Greenstile in Strathdon, the rock is a coarse biotite-gneiss, with abundant oligoclase and garnets, and contains sillimanite and andalusite as accessory minerals (6051). This alteration may be attributed to the contact metamorphism of the adjoining sill of diorite. Quarries have been opened near Broomhill in Deskryside in a fine-grained, dark, flaggy biotite-schist, with bands of calcareous schist or impure limestone. The calcareous schist is seen also at Bluefield and Reppachie.

Andalusite Schist.—Andalusite is abundantly developed in the schists along the extreme eastern margin of the Map as far south as Roman Hill. It first makes its appearance in the form of small knots or aggregations in the schists on the western slopes of the Upper Cabrach basin and increases in development to the eastward. The crags which crown the summit of the Buck of the Cabrach are formed of a massive somewhat coarse-grained rock of an interesting character (2965). It is composed of cordierite, andalusite, microline, quartz, two micas, magnetite, and tourmaline. This, and the other cordierite-bearing rocks referred to later on, will be found fully described in the section (VI.) dealing with the general petrology of this district (p. 35).

The rocks on Craigenscore and Scad Hills are composed of a finer-grained andalusite-schist; and in the Glen Laff Burn, which rises on the southern slope of the latter hill, a good section of these schists is exposed for some distance. Andalusite-schist also occurs on Meikle Firbriggs Hill, between the Deveron and Blackwater, and can be seen interfolded with quartzite along the course of the small burn that flows into the Deveron along the Banffshire county march.

A band of coarse gneissose rock is included in the foliated epidiorites along the southern slopes of Morven, where it extends for 3 miles across the heads of the Morven Burn to the granite of Culblean Hill. The rock is thoroughly foliated, and is composed of white mica, granulated quartz, garnet in rounded grains, and sheaf-like masses of sillimanite (3284). It probably represents the ordinary mica-schist of the region altered to a certain degree by the contact metamorphism of the surrounding igneous mass.

A similar origin may be assumed for the inclusions of gneiss that occur in the granite of Glen Gairn, between Tullochmacarrick and Cairndoor Hill. It is a fine-grained rock, intensely gnarled and crumpled, filled with strings of white quartz, and traversed in every direction by veins and apophyses of the contiguous red Cairngorm granite.

A marked feature in the whole of the schistose series is the change which often takes place in the character of the rock along the strike.

In the black schist zone, where the persistent outcrop of the limestone affords an indication by which the same horizon can be followed, garnetiferous schists pass northwards into much less highly metamorphosed slates and phyllites. Again, in the band that extends from the Don at Corgarff along the watershed to the Blackwater Forest, mica-schists can be traced passing into slightly altered felspathic clay slates, and these again into mica-slates and phyllites. These variations may partly be due to a system of complex folding, coupled with changes in the inclination of the axes of the folds.

A probably more potent cause is to be looked for in the existence of a mass of igneous rock underlying the schists at different depths below the surface and thus affecting them in varying degrees of metamorphism.

"Cromdale Hills Series."

This name has been adopted to denote the series of crystalline schists which occupy nearly the whole of the ground in this Map that lies to the west and north of the River Avon, and are particularly well developed in the range of the Cromdale Hills.

They consist of an assemblage of schistose quartzite, quartz-schists, mica-schists, quartzose and micaceous flagstones, uniformly holocrystalline and granulitic in structure. Generally a quartzose series, they have been separated from the Banffshire quartzites to the east on account of differences of character and structure that are, as a rule, easily recognisable. The Banffshire quartzite, as developed in this area, may be regarded as a homogeneous formation deposited under nearly uniform conditions of sedimentation. The sedimentary origin of the rock is clearly apparent to the eye, and even when the structure is more or less granulitic, the original clastic grains are never entirely destroyed. Deformation due to mechanical movement is an infrequent feature and confined to strictly limited areas.

The Cromdale Hills Series, on the other hand, represents a set of alternating shales and sandstones which have been converted, chiefly by dynamical metamorphism, into micaceous and siliceous schists and flagstones. These rocks are thoroughly granulitised, and their sedimentary origin is only occasionally to be recognised in the dark laminæ which under the microscope are found to be composed of heavy residues such as ilmenite and zircon. In addition to the granulitisation, the original mineral particles are drawn out in one determinate direction, giving a striped appearance to the rock in many places that at once catches the eye.

It will be observed that the dip-arrows, in the area occupied by this series, are engraved with a double shaft. This distinction from the ordinary dip-arrow has been adopted to indicate the fact that the apparent dip of the beds cannot be taken as representing the original inclination of the planes of deposition. The rocks of this region have been subjected to intense plication, and their apparently regular arrangement and uniform dip in the one direction, is, in reality, due to a complex system of isoclinal folds. So sharp and rapidly repeated are these folds, that where their crests have been removed by denudation, the appearance produced is that of regular parallel bedding, the strata being uniformly inclined in an easterly or south-easterly direction, and often at comparatively low angles.

The constantly recurring alternations of the micaceous and siliceous members of the series, though partly due to original differences in the nature of the sediment, are also, in great measure, caused by this system of rapid folding. On account of the paucity of sections, and the covered nature of much of the ground, it has been found impossible to differentiate these two types of rock in any great detail; but several of the broader bands of mica-schist have been mapped out, and are indicated on the Map by a difference of colouring and symbol.

The earth movements that produced the system of extreme plication referred to above have also been the cause of considerable mechanical deformation in the original particles of the rock. The cleavage planes thus produced are well developed in the softer and more felspathic portions, but do not always traverse the hard siliceous bands, against which they sometimes terminate in a strikingly abrupt manner. The cleavage

invariably follows the direction of the over-folding, which, over the northern part of the area, is W.N.W. to N.W., but changes to S.W. between Glen Dorback and the Cairngorm granite.

The eastern boundary of the Cromdale Hills Series enters the Map in the north at Tombreakachie in Glen Livet, and runs in a S.S.W. direction across Glen Chabet, Strathavon, and Glen Brown. Along the slopes of Carn Liath and Carn Damh the flagstones appear to dip beneath the black schists and limestone, but in Coire an Fuaraig and the Chabet Water they underlie the white quartzite of Tom à Chor. This is one of the few localities where the two quartzose series can be seen in close conjunction, and the difference between the flaggy quartzites and quartz-flagstones seen in the stream section and the massive quartzite on the hill above is well marked.

Southwestwards from this point a band of mica-schist and flagstone forms the eastern limit of the series as far as the granite of Allt Iomadaidh. These rocks are well exposed in the flagstone quarries of Cnoc Fergan and Dailbreac on the banks of the Avon; and on either side of the Bridge of Brown (2248). A short distance above the bridge, the burn of Brown has cut a deep channel through the rock, in which fine examples of "pot-holes" in various stages of formation are to be seen.

The Cnoc Fergan flagstone is a fine-grained, very flaggy, banded mica-schist, chiefly made up of quartz and felspar, with abundant scales of white and brown mica, the latter sometimes forming small aggregations. The structure of the rock is granulitic. The banding probably indicates the original planes of bedding, to which the foliation planes are generally parallel. These latter are remarkably equidistant and regular, and the rock readily divides along them in slabs of large size, well suited for paving purposes.

Returning to the northern part of the area, the observer finds the flaggy quartzite and quartz flagstones forming the range of hills that rise above the Avon on the east. The flaggy quartz schists on the north-east slope of Carn Ghrantaich, near the old distillery, contain bands of garnetiferous mica-schist, and also thin seams of crystalline blue limestone, with carious brown weathering.

The flagstones are visible at many points along the banks of the Avon between Dalrachie and Inverlochy, but since the course of the river runs pretty nearly parallel to the general strike of the beds there is little variation in the rocks of the river-sections. The apparent dip of the beds is from E.S.E. to S.E., at comparatively low angles, and striping showing a north-westerly movement is often distinctly visible.

But it is in the smaller streams that flow off the slopes of the Cromdale Hills that the best exposures of these rocks are to be obtained. In the lower part of the Allt na Eirinn, that joins the Avon at Kinardochy, the rocks are much folded and sheared. The crests of the folds can often be seen to be occupied by comparatively unmoved and massive quartzite. Further along the rapidly thinning limbs of the fold, where the material has yielded more readily to the increasing strain, the quartzite is converted into a fissile, quartzo-felspathic schist, in which white mica is plentifully developed. This structure is a common accompaniment of the folding among the quartzose rocks of this area. The burn affords a nearly continuous section of these sheared quartzites, passing towards the head of the stream into grey micaceous schists and flagstones.

The Allt na Caoire and the Allt Mòr, the next streams of importance to the south, afford sections very similar to that described above. In the lower part of the Allt Mòr there is a more rapid alternation of the quartzite and micaceous flagstone, and at the foot of the small tributary

the Allt Tarsuinn, a fine section is exposed showing the passage of the quartzite into thin fissile schist. The whole of the rock at this point shows signs of great movement, and is contorted and crushed along the axes of the folds. Similar phenomena are to be observed in the Allt an Douris, a mile further to the south.

The summit ridge and slopes of the Cromdale range are for the most part covered with hill-peat and drift; but the flaggy quartzites are seen at Creag Alltnaha, on the highest parts of Creag na Chaise and Carlag, and on the slopes above Glen Lochy.

The rock referred to in the preceding paragraphs as sheared quartzite or quartzite-schist appears under the microscope as a fine-grained, banded, quartzo-felspathic-micaceous-schist. The quartz and mica vary in amount and the felspar is sometimes completely absent. In the more thoroughly sheared portions, silvery white mica, in crystalline plates of uniform size, is the predominating mineral. These mica flakes are not bent where puckering occurs, showing that the crystallisation was later than the movements which produced the puckering. The dark laminæ are due to layers exceptionally rich in ilmenite, rutile, and zircon; and, no doubt, represent the original lamination of a fine-grained sandstone (4842, 4844–5).

The rocks described as flagstones are similar in structure to the above, but contain much more felspar and numerous plates of brown mica. They must also have had a sedimentary origin, but can now only be described as granulitic muscovite-biotite-schists.

On the west side of the Cromdale range the mica-schists become more predominant, and alternate rapidly with the quartzose members of the series. Very little rock is visible on the western slopes, and even the stream sections often show nothing but drift. It has, however, been found possible to trace the approximate boundaries of two of the larger belts of fissile mica-schist. One of these bands lies a little to the west of the watershed, and the rock is visible in the heads of the streams that flow off Carn Eachie. The other extends from the Allt Choire Odhair across Carn Dearg to the Leth Allt Mòr. The quartzites in this stream and in the neighbouring Leth Allt Beag give evidence of intense folding and interstitial movement. Lines of stretching running north-west are very distinct, the rock is thoroughly drawn ont and often shows beautiful "mullion-structure."

Passing westwards towards the Spey the schists show signs of further alteration which may be connected with the appearance of igneous intrusions, and due to thermo- rather than to dynamo-metamorphism. In the Haughs of Cromdale, and especially about Ballenluig, where veins of pegmatite first make their appearance, biotite is largely developed, and sometimes entirely replaces the white mica in the schists, which are thoroughly granulitic, gneissose, and sometimes garnetiferous (4846–8).

In that part of the area which lies south of Glen Dorback the ground is greatly obscured by peat and superficial deposits. The dry gorges of the Eag Mhòr (great notch) and Eag Bheag in the Braes of Abernethy have been cut through the banded flaggy quartzites and quartz-schists of the region and an intercalated belt of flaggy mica-schist, the latter of which is slightly shifted by a cross fault running E.N.E. and W.S.W. A similar assemblage of rocks is seen at the head of the Allt na h'Airidhe and in the burns that flow off Carn Bheur and the Geal Charn. No rock is visible between this range and the Caiplich Water, but that stream gives an almost continuous section for nearly six miles across the strike.

The boundary of the Cromdale Hills Series crosses the Caiplich Water at a point about ¼ mile south of Carn Ruadh-bhruaic, where sheared quartzite is seen in the deep gorge dipping beneath a band of corrugated graphitic-

schist. The quartzite is succeeded in a few hundred yards by a noticeable band of silvery, well-foliated muscovite-schist. This band crosses the flanks of Geal Charn Bheag, but thins out rapidly to the north-west. From the east side of the stream it extends over Coire Riabhach and the hills on the north side of Glen Loin to the Avon. On the steep hill-sides that rise above the Loin Burn, the silvery greenish-grey felspathic mica-schist is seen interfolded with bands of quartzite. A specimen from Creag na Cadha shows brilliant micaceous lustre on the somewhat uneven planes of schistosity, and is composed of quartz, felspar (generally striated), white and brown mica, and chlorite (5448). The same band forms the cliffs on the west side of the Avon below Inchrory. As these mica-schists approach the granite of Ben Avon, they undergo further alteration under progressive contact metamorphism, and gradually pass into a flaggy granulitic and sometimes granitic gneiss in which cordierite is plentifully developed. This rock is more particularly described in the section treating of the contact-metamorphism of the granite. Opposite Inchrory Lodge the gneiss contains a band of malacolite-tremolite-rock, which probably represents a highly altered limestone (5454).

Returning to the Caiplich section, the mica-schist is found to be succeeded by a flaggy quartzite which extends for a short distance above the sudden bend made by the stream to the west. From this point westwards nearly to the edge of the Sheet, the stream affords a continuous section of gneissose flagstones with bands of quartz-schist. The general type of rock may be described as a fine-grained, banded, flaggy granulitic biotite-gneiss, composed of quartz, felspar, and rich brown biotite, with occasionally some small garnets. The banding is due to variation in the amount of biotite (5455). The regularity observed both in the planes of foliation and in the arrangement of the isoclinal folds is very remarkable. For nearly six miles the rocks preserve a constant inclination to the north-east and rest at a generally uniform and moderate angle.

IGNEOUS ROCKS.

Mica-Diorite, Epidiorite, and Hornblende Schist.

The belt of basic rock that extends across the eastern portion of the Sheet forms part of the great set of basic intrusions that stretch in a south-west direction from the coast of Banffshire across the Central Highlands to the western sea. It will be observed that the boundaries of the diorite area generally follow the strike of the schistose rocks, into which it has been intruded in the form of a sill or series of sills.

The rock varies considerably in character and composition from north to south. In the Upper Cabrach district, and southwards by the head waters of the Deveron to the rocky hills above Sloggie and Ballochduie, it is a typical mica-diorite, massive, and usually coarsely crystalline throughout, or with the biotite arranged in large porphyritic aggregates in a finer crystalline matrix of hornblende and plagioclase felspar. A small amount of quartz is usually also present.

In the lower part of Glen Bucket, south and east of Uppertown, hornblende becomes the most abundant and important constituent, occurring generally in rod-shaped or subacicular crystals in a matrix of plagioclase felspar (often secondary) and a little quartz, with occasional large scattered crystals of biotite. It is in this rock that veins of the beautiful variety known as "Glen Bucket Diorite" occur, with large well-formed crystals of hornblende up to 3 and 4 inches in length, set in a finely crystalline

matrix of white triclinic felspar, with a few large crystals of biotite. The Glen Bucket Diorite can be seen in place at several localities near Uppertown, Belnaboth, and Milltown, and is frequent in loose blocks on Clashanteple Hill and Tom na Gabhar along the watershed between Glen Bucket and Strathdon.

Along the eastern boundary of the area, between Meikle Forbridge Hill and the River Don, the rock is distinctly foliated, and may be described as a foliated quartz-biotite-diorite (6048, 6053). In a specimen from Dockington hornblende, biotite, quartz, and plagioclase are present, the hornblende occurring in irregular ophitic masses, with inclusions of plagioclase, iron ores, and apatite. The rock of Ben Newe (6047) is very similar in character, but contains sphene and chlorite as an alteration product. The plagioclase is more or less idiomorphic and often zoned, and is in a large measure labradorite, but the outer portions of the zoned individuals are somewhat more acid.

The foliation of the marginal portion of this area is so complete, and the rock so gneissose in character, that it has been found difficult in places to draw a satisfactory divisional line in the field between the foliated diorite and the coarse biotite gneiss with which it is in contact on the east.

Epidiorite.—A line drawn westwards from Quarry Wood along the hill slopes above Strathdon to Howe in Glen Nochty will roughly indicate the boundary of the area in which epidiorite, derived from an original gabbro, is the predominant rock. The amount of alteration varies considerably, and though the term epidiorite has been used to include all the rocks in this part of the area, there are several localities where gabbro would still be the more fitting designation. Thus the beautiful rock exposed in the banks and channel of the Don at Pooldhulie Bridge is mainly composed of diallage and labradorite (2804–5). The microscope also reveals the presence of irregular black patches which may represent original olivine crowded with magnetite-dust, though no olivine can now be definitely recognised. In addition to the above, a fair amount of pale-green secondary hornblende is present in aggregates, which often form narrow zones round the diallage crystals into which they merge and from which they have doubtless originated. The felspars are sometimes crushed, and the larger uncrushed grains often show strain phenomena under crossed nicols. The main mass of this rock shows but slight traces of foliation, but contains numerous thoroughly foliated bands with beautiful *augen*- and *flaser*-structures, the "eyes" being formed of a black substance surrounded by alternate black and white lenticular folia tailing off into thin streaks. These eyes consist partly of large ragged individuals of greenish-brown primary hornblende, and partly of pale hornblende probably replacing augite. The dark streaks are largely made up of hornblende and iron ores, the white folia of crush mosaic, with here and there large individuals of felspar showing marked strain phenomena. Apatite is also an important accessory. The original rock here was probably a hornblendic gabbro, and its present structure is no doubt due to mechanical movement.

The rock in Quarry Wood, above Castle Newe (2810), shows a more complete alteration in the diallage and a partial saussuritisation of the labradorite. Iron ores also occur in compact irregular patches. In road-side quarries at Coul of Newe and Forbestown, bands of well-foliated rock traverse a massive epidiorite, and here, as well as at Pooldhulie, there are veins of very coarse hornblende-pegmatite, which seem to have been developed along lines of shear.

The amount of foliation increases southwards from Strathdon, and the

localities where it is best developed are indicated on the Map by the symbol ϕ. A coarse-grained epidiorite, showing marked flaser-structure, can be seen in a small burn 250 yards south of Belnagaul in Glen Carvie (6055).

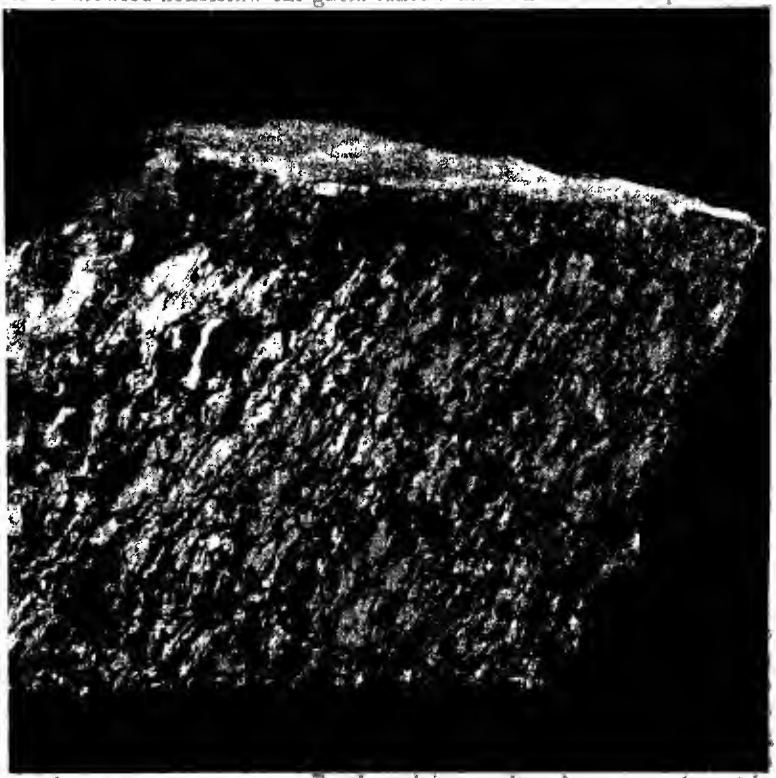

Fig. 3.—Olivine-Gabbro showing marked "augen" and "flaser" structure, Pooldhulie Bridge, Strathdon.

It is a very felspathic rock in which the phacoids are formed of large individuals of plagioclase felspar often strained and broken, and surrounded by a white granular substance resembling saussurite, and the *flaser* of a finer-grained intermixture of hornblende and granulitic felspar. Hornblende also occurs in large irregular masses, and iron ores and chlorite as accessory minerals.

Hornblende-Schist.—In Glen Ernan, between Edinglassie and Braesashiel, the epidiorite is also well foliated and sometimes passes into a regular hornblende-schist, in which the foliation planes have a general N.N.E. strike. Hornblende-schist is also exposed in the bank of the river at Mill of Glen Conrie. The felspars are here partly fresh and partly saussuritised, and occur in large twinned individuals showing more or less strain, and also as the constituents of a mosaic.

South of Allt a Bhrsabadair Hill the foliation steadily increases in amount, and the rocks of Glen Finzie, Glen Lary, and the country extending eastwards to the boundary of the Culblean granite are found to consist to a large extent of thoroughly-foliated hornblende-schists having a N.N.W. strike. They are composed of a holocrystalline aggregate of

plagioclase and hornblende, with ilmenite, iron ores, and sphene as accessory minerals. The felspar is secondary and generally occurs in the form of a mosaic, while the hornblende shows marked parallel structure. This parallel orientation is particularly well seen in the thoroughly schistose rocks of Glen Lary. These hornblende schists have evidently been derived from an igneous rock—probably gabbro—by dynamical metamorphism.

The massive, fine-grained crystalline rock that forms the conspicuous hill of Morven, and is well seen in the craggy gorges of the Deskry Water, rarely shows any trace of foliation, but is essentially an epidiorite, in which green hornblende has entirely replaced the diallage of the original rock. This hornblende occurs partly in the fibrous uralitic form and partly in the form of aggregates. Apatite is very abundant as an accessory (2812).

Another belt of epidiorite, connected in the south with the larger mass already described, crosses the Don between Garchory and Delahaish. The long parallel inclusions of slate and limestone preserving a constant direction of strike, that are shown on the Map to the south of Tornahaish, emphasise the sill-like nature of the intrusion; and the sudden increase in its breadth at this point is probably due to the coalescing of several sills or to the repetition by folding of the same sill.

Along the same line of outcrop to the north, several groups of parallel intrusions of epidiorite occur in the form of thin bands intercalated with the schistose rocks of the region. The thick peat that covers the hills prevents them from being traced for any great distance, but they are well seen in the stream sections at the heads of the Ernan, Nochty, and Bucket Waters. The rock composing these sills is a porphyritic epidiorite containing rounded or sub-angular crystals of white felspar set in a dark-greenish matrix. The porphyritic felspars have been saussuritised, with a developement of epidote, zoisite, and white mica. The ground mass is an aggregate of lath-shaped plagioclase, pale secondary hornblende, and iron ores; and traces of original ophitic structure are present (6057). No foliation has been observed in these rocks, but in a band of quartzite that crosses the head of the Deveron, 3 miles south of Kirkton of Cabrach there occurs a single sill with marked schistose structure, composed of hornblende in large irregular individuals and aggregates set in a granulitic matrix.

Gabbro.

The basic rocks that occupy the low ground along the course of the Blackwater, from the edge of the Sheet southwards to Cairnbrallan, no doubt represent the northern extension of the western margin of the great sill.

The isolated patches of serpentine that have been mapped between Cairnbrallan and the Green Hill indicate a connection, which, though perhaps interrupted to a certain degree by folding, may be more complete than that represented on the Map. A phenomenon common to this and other basic intrusions in the north-east of Scotland is the increase of basicity towards the margin of the mass by the segregation of the denser constituents of the original magma. The passage from the acid quartz-mica-diorites of the Cabrach and Glen Bucket to the epidiorites—originally augite-bearing rocks—of Pooldhulie and Glen Ernan has been already described. In the Blackwater area the rocks were originally still more basic in character, and, though considerably altered, still belong more to the pyroxene than to the amphibole group, while the ultra-basic portions are now mostly in the form of serpentine.

Immediately north of Blackwater Lodge the rock is usually a fine-grained aggregate of plagioclase and pyroxene, the former being the predominant mineral (2963–4). The pyroxene is probably diallage, and is altered into a pale green hornblende along the periphery of the crystals. With this is associated a coarser rock very rich in augite, which occurs in large greenish crystals showing fine lustre-mottling. These crystals are partly altered into acicular and fibrous hornblende and show evidence of internal movement relating to extraneous pressure.

Throughout these rocks there are foliated bands resembling the Pooldhulie gabbro, and the small burns that flow down the hillside on the east side of the glen show sections of thoroughly foliated and sometimes slaty rock, that may be called a gabbro-schist. On the hill of Stroninch, further to the south, the rock contains more hornblende (5447).

Serpentine.

Serpentine is confined to the eastern portion of the area, where it occurs in connection with the basic intrusions, and may be regarded as due to the decomposition of the ultra-basic elements which have segregated along the edge of the mass.

The largest area of serpentine in the Sheet lies between Glen Nochty and Glen Ernan, and forms the Green Hill, a small outlying patch also occupying the Coulick Hill above Belnabodach. The typical rock of the Green Hill is a compact dark green serpentine containing a few irregular patches of enstatite. Under the microscope the bulk of the rock is shown to be composed of serpentine showing the mesh-structure due to finely divided iron oxide. The meshes sometimes contain cores of unaltered olivine. There are also larger patches of serpentine, mostly free from iron oxide, which contain cores of unaltered enstatite. On Coulick the rock is a mottled green serpentine in which alteration has proceeded further, and there is no trace left of the original minerals (6058–9).

Along the southern margin of the Green Hill area the amount of serpentinisation is very variable, and about Braesashiel there is a very gradual passage from the foliated epidiorite of Glen Ernan into a serpentine in which the planes of foliation are still distinctly visible.

A mass of ultra-basic rock which has been entirely converted into serpentine is intrusive in the schists at the head of Glen Kindie, where it occupies an area more than a mile in length. It is a mottled green rock, often veined with chrysotile, and shows foliation near the edge of the mass. Near Rinmore it has a crushed and sheared appearance, and contains veins of green chlorite, talc, and fibrous serpentine. Dendritic oxide of manganese and iron ores are also present. A smaller patch of this rock at Lochery, half a mile further up the burn, is not so completely altered, and contains chromite. This mineral also occurs abundantly in places on the Green Hill.

The conversion of the ultra-basic portions of the rock in the Blackwater Forest into serpentine has been already referred to. The amount of serpentinisation varies in the different masses, the largest of which is found at Blackwater Lodge. The rock is usually a compact, somewhat hard, black serpentine, veined with light and dark green, and weathering with a coat of rusty yellow. In some of the other areas along the stream side, the original crystals of olivine can still be recognised (1769–70).

Other masses of serpentine are found in the Upper Cabrach. The largest of these extends eastwards from the Deveron at Powneed, along the foot of the Buck, and there are smaller patches at Redford, and north of Mount of Haddoch at the edge of the Sheet.

On Clachcurr Hill, between the Deskry Water and the River Don, and on the Deskry below the farm of Barns, there are two small intrusive masses of a massive black hornblende-peridotite, containing large irregular individuals of lustre-mottled hornblende (6052). The component minerals of this rock are found to be enstatite, olivine, hornblende, secondary serpentine, iron ores, and a green spinel.

Contact Metamorphism of the Basic Rocks.

The covered nature of the ground gives few opportunities for a satisfactory examination of the rocks in immediate contact with the basic intrusions; but the evidence available points to the generally slight effects exerted in this direction.

Between Glen Bucket and the Deskry Water, the mica-schists that flank the great diorite sill show signs of alteration that may be due to contact metamorphism. At Greenstile and Buchaam in Strathdon, and on the southern slopes of Ben Newe, the mica-schist passes into a coarse granitoid gneiss containing large garnets, sillimanite, and a little andalusite. A similar rock, with large garnets, also occurs on Creag an Sgor and Millhuie Hill.

At Cairnbrallan, in the Blackwater Forest, there is a rock, described by Mr Teall as a more or less schistose mica-hornfels, that exhibits many of the characteristic structures due to contact metamorphism, possibly in this case induced by the neighbouring gabbro intrusion.

Foliated Granite.

In the eastern portion of the Sheet there are several small patches of granite—indicated by the symbol G ø—all of which are more or less distinctly foliated, the direction of foliation coinciding with that of the surrounding metamorphic rocks. These granites must consequently have been protruded prior to the movements that produced the common foliation, and therefore belong to an acid intrusion earlier than that which has been described under the head of the "Cairngorm Granite."

At Lochery, in Glen Kindie, and on the hills bounding that glen on the west, the foliated granite appears in several localities as a white granitoid gneiss in which the biotite is arranged in wavy lines and aggregates in a matrix of quartz and felspar (6049). Under the microscope the rock is found to be made up of microcline, plagioclase, biotite, and quartz. Small granular patches of micro-pegmatite and quartz occur as inclusions in the microcline, while the biotite contains apatite and zircon (?).

West of Belnacraig, several bosses of well-foliated grey biotite-muscovite granite are intrusive through the Glen Bucket diorite; and in Glen Ernan a highly crushed and metamorphosed rock, that may be regarded as a sheared granite, forms a lenticular mass about a mile in length extending through Braeside Wood above Edinglassie. This latter is composed of grains of microcline and quartz, surrounded by layers of silky muscovite, and embedded in a confused aggregate of crushed quartz and biotite (2970).

Cairngorm Granite.

The large mass of granite that occupies the southern margin of the Map, including the northern spurs and slopes of Beinn à Chaoruinn, Beinn à Bhuird, and Ben Avon, and the lower hills between the Gairn and Don, represents the eastern extension of the great intrusion of acid rock that

forms the high mountain plateau of the Cairngorm range, and to which the name Cairngorm Granite may conveniently be given.

The Cairngorm Granite is intrusive in, and consequently later than, all the rocks represented in this Sheet with the exception of the Old Red Sandstone, the occurrence of fragments of this granite in the conglomerates of Delnabo proving the priority of origin of the former. No signs of foliation have anywhere been detected in this rock, which over a wide area varies very little in character. It may generally be described as a biotite-granite, the component minerals being orthoclase, plagioclase, quartz, and biotite. The orthoclase varies in colour from pale flesh-colour to deep red, and in the coarser varieties of the rock occurs in porphyritic crystals one to two inches in length. In a specimen from Glen Avon (5247) indistinct micro-perthitic and microcline structures have been detected in this felspar under the microscope. The plagioclase felspar can usually be identified as oligoclase, and is generally more or less idiomorphic with regard to the orthoclase and quartz. Quartz is a constant constituent, usually interstitial, or forming rounded blebs in a finer-grained matrix of quartz and felspar. Biotite is sparsely distributed through the rock in small scattered flakes, and is sometimes entirely absent. In specimens from the north summit of Beinn a Bhuird its place is taken by yellow aggregates of colourless mica, probably pseudomorphs after some other mineral. Sphene occurs as an accessory mineral, irregularly distributed through the coarser type of rock in Glen Avon, and occurring in nests in certain places (5458).

On the south-east slopes of Ben Avon, in a small area that extends along the west side of the River Gairn from the edge of the Map to a point a little above the bridge, the ordinary Cairngorm Granite passes gradually into a rock of a more basic character which from its composition may be classed as a quartz-mica-diorite or tonalite. It is composed of pale green hornblende, often fibrous and probably secondary, brown mica, plagioclase felspar and quartz, with iron ores and apatite as accessory minerals. A similar rock occurs on the south-east shore of Loch Builg (3813, 3817).

On the exposed mountain tops the felspathic elements of the granite yield readily to atmospheric influences, and the rock disintegrates into a coarse quartzose sand or gravel, which covers parts of the summit plateau to a considerable depth. The hardest portions weather out into isolated tower-like masses remarkable for the tabular weathering induced along their parallel horizontal joints. The lower slabs are often beautifully under-cut and polished by the sand that is continually driven against them.

The upper surfaces of the "tors" on Meall na Gaineimh, at the eastern end of Ben Avon, are hollowed out into numerous basin-shaped cavities, usually circular but sometimes elliptical in form, and varying from 1 to 4 feet in diameter, and from a few inches to 3 feet in depth. These "wind-pot-holes" generally contain more or less rain water and some loose quartz gravel, and have evidently been produced by the whirling round of these quartz grains in the water, under the furious eddying winds that sweep over the mountain tops.

Culblean.—The Cairngorm Granite appears again in the south-east corner of the Map, forming the Hill of Culblean. It is here coarsely crystalline, and shows marked parallel jointing or pseudo-stratification. Segregration quartz-veins, containing crystals of "cairngorm" and amethystine quartz in drusy cavities, are frequent.

Glen Livet.—A considerable tract of granite is found in the Braes of Glen Livet, extending along the courses of the Upper Livet and Bly waters, from Poolwick and Demickmore to the slopes of Carn Bruar and the

Eachrach. It occupies the lowest ground in the basin, and probably represents a portion of the underlying granite floor exposed by denudation; the quartzite hills under which it appears to pass rising steeply on either side of the flat expanse of the Convene Muir. The Glen Livet granite is mostly of the ordinary Cairngorm type, coarse-grained, with large crystals of flesh-coloured orthoclase. On the Kymah Burn, near the western boundary of the mass, it is intermediate between a true granite and a porphyritic micro-granite, there being a sharp distinction between the minerals of earlier and of later consolidation. The porphyritic constituents are orthoclase, plagioclase, quartz, and biotite, set in a micro-crystalline aggregate of quartz and felspar (5246).

Dorback.—A third granite area of importance occurs in the Braes of Abernethy, along the north slopes of Glen Dorback and the upper course of the Allt Iomadaidh. The sections exposed in the rocky banks of that stream show a considerable variation in the nature of the rock. Northwards of Rynetrick it is a coarse, flesh-coloured biotite-granite, with occasional muscovite, while at Straancamernich, 1½ mile to the south, it is of the ordinary Cairngorm type. Between these two points the rock becomes gradually more basic in composition, and passes through the stages of hornblende-granite and quartz-mica-diorite into a pyroxenic rock of a very remarkable character. The latter is well exposed in the gorge immediately north of Letterauchten, where it appears to the eye as a massive rock containing large crystals of hornblende set in a fine-grained greenish matrix (4854). Under the microscope the constituents are found to be hornblende, augite, striated felspar, biotite, and sphene, the last two minerals often occurring as inclusions in the larger crystals of hornblende. The groundmass is composed of small idiomorphic crystals of a pale green pyroxene embedded in large ophitic masses of labradorite or some allied felspar, the latter showing fine lustre-mottling on cleavage faces. It is difficult to class this rock, but it may be provisionally regarded as an augite-diorite. There is no evidence to show that this mass of basic rock has had a different origin from that of the contiguous granite, into which it passes by a gradual decrease of basicity, and of which it may be regarded as an early basic segregation. The coincidence of a large inclusion of limestone with the approximate boundary of the augite-diorite, suggests a possible origin of some of the pyroxenic material. The approximate area occupied by the augite-diorite on the Map is indicated by a different colour and symbol. The Dorback granite shows no trace of foliation, and from the general character of its acid portion may be regarded as belonging to the Cairngorm intrusion. It contains numerous inclusions of quartzite, schist, and limestone, the two latter being usually much altered and mineralised.

Besides these larger masses there are many smaller granite intrusions in different parts of the area. Some of these show pegmatitic structure, as in the mass above Candacraig in Strathdon, and the veins that traverse the gneiss of the Tomdubh Burn on Deskry-side.

Quartz-Porphyry, Felsite, Aplite.

These rocks are most abundantly developed in and in the neighbourhood of the eastern extremity of the Ben Avon granite mass. The black schists and limestones about Inchrory contain several sills of white and red felsite that are well seen in the cliffs above the Lodge, at the Foal's Craig, and in Glen Builg. Dykes of red felsite of later consolidation also traverse the granite at Tullochmacarrick and Easter Sleoch in Glen Gairn.

A vein of aplite, composed chiefly of white milky quartz, with a little

white felspar, fringes the granite along the west bank of the Builg Burn, and is continued for a short distance up the Allt Gaineimh. Another vein of white, brecciated-looking quartz, which passes in places into an aplite by the addition of felspar, has been traced for more than 2 miles through the granite of Ben Avon, from Da Druim Loin to the head of the Slochd Mhòr. At the head of Slochd Bheag it reaches a breadth of 60 or 70 yards, and contains a good deal of greenish epidotic felspar. Crystals of beryl have also been found in it near this spot.

Intrusive masses of pink quartz-felsite occur on the west side of the Peat Hill at the head of Glen Kindie, and at Dalrossack and Buchaam in Strathdon. There are also many other smaller intrusions of rocks of this class in the form of dykes or sills in various parts of the Sheet. A thin sill of acid rock showing marked spherulitic structure occurs in the quartzite of the Muckle Fergie Burn, rather more than half a mile above its junction with the Avon. The rock is a light reddish-coloured felsite, with brick-red spots crowded thickly together and sometimes coalescing into more or less parallel bands. A full description of this remarkable rock will be found in the appended report on the rocks of the district by Mr Teall.

Contact Metamorphism of the Newer Granites.

Owing to the amount of hill-peat and drift that covers the foot-hills of the Cairngorm range, there are few localities where the relation of the granite to the surrounding rocks can be satisfactorily seen. Along the course of the river Avon, for about a mile above Inchrory Lodge, good sections of the rocks in contact with the granite of Ben Avon are exposed. These consist of alternations of mica-schist with quartzite and quartz-schist, both traversed by apophyses and veins emanating from the contiguous granite. The mica-schist, which represents the originally more argillaceous members of a varying sedimentary series, has been altered into cordierite-gneiss, which is well seen at the Linn of Avon. It is a dark, medium-grained gneissose or schistose rock, composed of quartz, felspar, brown mica, cordierite, and, in one specimen, a little pleochroic andalusite; and in structure is in part granitic, rather than granulitic.

The more siliceous bands, though perhaps as profoundly modified, show less change among their constituent minerals. The development of a ferro-magnesian mica in the quartzites as they approach the granite is, however, a constant phenomenon of contact metamorphism in this region. The quartzites between the Linn of Avon and the Loin Burn contain abundant felspar and rich brown (contact) mica; the main constituents are irregular in form and interlock with one another, and partial granitisation has in great measure obliterated the original clastic nature of the rock.

In addition to this local metamorphism in the immediate neighbourhood of the granite masses, there is also evidence of what may be described as contact-metamorphism on a regional scale among the schists and slates of the central portion of the Sheet. The continual variation in the stage of crystallisation of these rocks along the line of strike from N. to S., and the sporadic development of such minerals as garnet, staurolite, kyanite, and andalusite at a distance from the visible igneous masses; are phenomena difficult to explain otherwise than as due to a thermo-metamorphic agent, acting with varying degrees of intensity over different parts of the area. The striking similarity in character and composition, and the mode of occurrence of the various masses of unfoliated granite in this region, suggest the strong probability of their being connected beneath the surface. Such a floor of igneous rock, underlying

the schistose rocks at varying depths below the surface and appearing at the surface in the great Cairngorm protrusion, and the smaller areas exposed by denudation in Glen Livet and Abernethy, would seem sufficient to produce the different phases of metamorphism above referred to.

The contact-metamorphism of the Cairngorm granite affects a wide area in the Central Highlands, and will be more fully discussed in a future Memoir on the region in general.

Lower Old Red Sandstone.

The principal outlier of Old Red Sandstone extends from the hill-slopes west of Glen Brown to the Water of Livet at Tombae, and occupies an area nine miles in length, with a maximum breadth of 2½ miles at Tomintoul decreasing rapidly north of the Feith Musach to a few hundred yards in Glenlivet. This outlier has been described by Hay Cunningham [1] and by Sir Arch. Geikie.[2]

The deposit attains its greatest thickness on Carn Meadhonach, 1925 feet above sea-level, where upwards of 500 feet of conglomerate must be represented. There is a strong overlap to the west, and the strata thin out rapidly along the western slopes of Glen Brown, where the deep gullies cut by the Allt na Claise Moire show coarse angular breccia and conglomerate with thin bands of sandstone, resting unconformably on the denuded surface of the underlying quartzite. Here and in the Ailnack gorge, the conglomerate can be seen wrapping round protruding stacks and knobs of the older rocks.

The conglomerate first appears in the Ailnack gorge at the bend immediately south of Lochan Uaine, and dips gently to W.S.W. Its junction with the underlying black schist and limestone is well seen as it creeps obliquely up the steep side of the ravine. Nearly a mile further east, a fault running W.N.W. across the Innis Bhreac brings the boundary down again to the bed of the stream, the faulted junction with the black schist being visible in the cliff. At the second bend below this point, the unconformable boundary again leaves the gorge, and crossing the Little Ailnack, where a thin cake of conglomerate overlies the black schist, extends N. and finally W. round the slopes of Carn Meadhonach to the Burn of Brown.

A few hundred yards further to the E., a powerful N. and S. fault with a down-throw to the east, that runs from the Ailnack along the foot of Carn Meadhonach to the Avon at Lynchork, again brings down the Old Red Sandstone, and the conglomerate is now seen on both sides of the gorge, and along the west bank of the Avon by Poll nan Eun.

The conglomerate can be well observed in the Ailnack ravine, and on the E. bank of the Avon at Delnabo Bridge and Ceapach. It is a coarse, tumultuous assemblage of large well-rounded and occasionally sub-angular blocks of crystalline quartzite of local origin, set in a finer conglomeratic matrix, also chiefly composed of quartzite. Some of these blocks are as much as three or four feet in diameter. Besides the quartzite there are included fragments of various varieties of mica-schist, and a few rounded pebbles of Cairngorm granite. The character of the deposit is markedly torrential, and the included stones often show false-bedding inclined to W.N.W.–W.S.W. at high angles; while the true dip can only be ascertained from the inclination of the intercalated bands of sandstone.

The great thickness of this conglomerate points to a long continued subsidence of the floor upon which these delta deposits were laid down;

[1] *Trans. High. Soc.*, 1843, vol. xiv.
[2] *Trans. Roy. Soc. Edin.*, 1878, vol. xxviii. p. 426.

but periodic interruptions in this downward movement are indicated by the wedge-shaped beds of sandstone that appear on the W. bank of the Avon opposite Tomintoul, and thicken out to the N., accompanied by a corresponding gradual thinning-out of the conglomerate in that direction.

A quarry opened in these sandstones opposite Fordmouth, shows thick-bedded greenish-grey and red freestone, with seams and galls of red clay. The dip is W.S.W. at 20°, and the rock resembles in character the Quarry-Hill sandstone of the Rhynie basin. Breccia and conglomerate are seen along the banks of the Conglass Water between Rhynamarst and Delnalyne, and flat micaceous sandstones at the Bridge of Conglass. Beyond a few exposures of flaggy green and red sandstone in the Reidh-beag Burn, little is seen of the rock between the Conglass and Glenlivet until the deep ravine below Croftbain is reached, where alternations of red sandstone and coarse conglomerate, brought against the reddened quartzite of Carn na h'Iolaire by a small fault, are exposed for some distance.

The Cabrach.—The Upper Cabrach outlier is bounded on the W. by a fault which throws the sandstones down against the metamorphic rocks that form the western boundary of the Cabrach basin. The exact position of the bounding fault is usually obscured by superficial deposits, but its approximate course is indicated by a line running N.E. from Aldivalloch by Aldunie to Tornichelt, where it crosses the river Deveron and follows the course of the Burn of Bank to the Diamond Stripe, whence it bends to the N. and leaves the Sheet. The reddened soil and sandy drift, full of rounded stones derived from the conglomerate, that covers the hill-slope above Auchmair and Dykeside, indicate the position of the unconformable eastern boundary; and at the roadside near the Bridge of Kirkton the sandstone is seen resting on an eroded surface of decomposing mica-diorite, filling up the interstices between the weathered-out bombs of the latter, and thus presenting the appearance of a breccia or conglomerate.

At this point a cross fault shifts the unconformable boundary to the west side of the Rooster Water.

There are few exposures of the rock in this limited area. Soft, incoherent, red or grey micaceous sandstone is seen at various points along the banks of the Deveron and Rooster Water; and in the Burn of Bank there are intercalated with it bands of coarse incoherent conglomerate composed of large well-rounded quartzite pebbles. These are often completely shattered in the matrix.

No very reliable dips can be observed. Near Tornichelt, Milton, and Aldivalloch the beds are inclined S. of W. at very low angles.

The loose conglomerate and soft incoherent sandstone of this area are very similar to the rocks included in the Tillybrachty Sandstone zone of the Rhynie outlier.

No traces of organic remains have yet been discovered in any part of the Old Red Sandstone of this district.

PLEISTOCENE AND RECENT.

Glacial Deposits.

Striated Rock-Surfaces.—There are few direct proofs of the direction of the ice-flow over this district. From the rapid disintegration of the rock on the mountain-tops and the covered nature of the lower hills, ice-scratched surfaces are rarely met with. The few striæ that have been observed have a general north-easterly trend, and this fact, combined with the distribution of erratic blocks over the area, indicates an ice-movement

radiating out between N.E. and E. from the great Cairngorm plateau in the S.W. as a centre of dispersion.

Erratic Blocks.—Carried boulders of the Cairngorm granite are found in all portions of the Sheet, from the Cromdale Hills in the N.W. to Morven in the extreme S.E. They appear on the very summit of the latter hill at an elevation of 2862 feet above sea-level, indicating a minimum thickness for the ice-sheet of over 2000 feet. Additional evidence of the easterly movement is also afforded by the occurrence of fragments of the well-known Glenbucket diorite on the east side of Glenkindie and in the adjoining Sheet (76). No erratics have been observed on this part of the Cairngorm range above a height of 3000 feet, but the drift in Glenavon, on the north side, often contains fragments of gneiss and schist that must have come from the W.S.W. across the lower parts of the watershed—probably through the Larig an Laoigh.

Boulder Clay.—With the exception of the mountainous area in the S.W., and the higher hill-tops, nearly the whole of the country represented in this Map is more or less thickly covered with glacial drift. As is usual in the East of Scotland—where the scouring effect of the later valley glaciation is much less pronounced than on the west side of the watershed,—boulder clay is by far the most important and widely distributed member of the glacial deposits, and covers a wide area, lying deeply over the low ground and along the flanks of the hills, and often sweeping right over the cols and lower summits.

It varies in character according to the nature of the underlying rocks. In the area occupied by the granite it is reddish in colour and generally loose and sandy, but sometimes passes downwards into hard red till. North and east of Tomintoul it owes its red colour to the Old Red Sandstone, and contains numbers of well-rounded quartzite boulders derived from the disintegrated conglomerate. The valley drift in the eastern part of the Map is a typical boulder clay, greenish or grey in colour, and filled with sub-angular stones. Towards the surface it changes colour from the oxidation of the ferruginous materials, and becomes earthy and incoherent.

The majority of the included stones are usually composed of quartzite and quartz-schist, the most indestructible rocks in the district. Diorite fragments are abundant in the east, and blocks of Cairngorm granite are universally present in more or less abundance. Boulders derived from a distance outside the Sheet have rarely been recognised. The thickness of the boulder clay in the valleys is well seen in the upper part of Glen Brown, where the stream is cutting through the drift deposit that fills up a preglacial valley. The banks of the burn give sections showing at least 60 feet of drift, loose and sandy above and passing downwards into yellow till, while the stream has in many places not yet reached the rock below.

Sand and Gravel.—Beyond the ordinary stream alluvia, these deposits are nowhere conspicuously developed in this area. In the Braes of Abernethy a considerable extent of sand and gravel occurs along the course of the Dorback Burn, and marks the former site of a glacial lake. The margin of this lake at different levels is indicated by the successive fragments of horizontal terraces that fringe the slopes of the Geal Charn and Carn Sheilg. The highest of these has an elevation slightly exceeding 1500 feet, the lowest of 1300 feet—above sea level. This lake was probably formed by the damming up of the lower end of Glen Dorback by the great glacier which flowed down Strathnethy from the high Cairngorms, at a time when the ice was already melting from the lower hills. Its waters may have escaped through the dry gorge below Lynbreck, at the head of Allt Choire Odhair.

The high banks of the Dorback Burn, immediately below the Lodge, give good sections of the deposit, the nature of which indicated still, or very gently running water conditions, with occasional irruptions of coarser stream-borne material. It is mostly a finely laminated sandy clay, with lenticular beds and nests of fine and coarse gravel. The lamination of the finer material is generally horizontal, but sometimes shows signs of squeezing and contortion, such as might be produced by the action of ice grounding in shallow water. The sands and gravels are in places false-bedded.

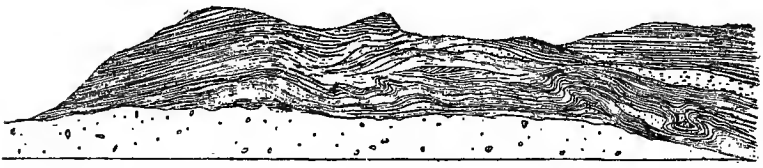

Fig. 4.—Section showing contorted sand with lenticular beds of gravel. Dorback Burn, Braes of Abernethy.

In the lower part of Glen Nochty there is a thick deposit of sand and gravel which may have a partly glacial origin. The high banks and denuded ridges seen on either side of the valley at Howe and Belnabodach are composed of sand with intercalations of coarse gravel. The structure of these mounds is kamiform, and the bedding is often parallel to the sides of the mound.

Moraines.

Evidences of the later valley glaciation in this district are, with a few trifling exceptions, confined to the glens and corries of the Cairngorm mountains.

The Slochd Mhòr, the Slochd Beag, Coire Ruairidhe, and other glens on the south side of Glen Avon, have their independent system of lateral, medial, and terminal moraines, indicating the course and extent of the glacier in each particular valley. At the mouth of the Slochd Mhòr, there is a group of flat-topped, terraced, morainic ridges, of very regular form and great thickness. They are composed of granite detritus, chiefly in the form of sand and fine gravel, and are probably to some extent of fluviatile origin, owing their present regular form to the dressing action of the stream, that is now cutting its way down through these thick glacial deposits.

Lateral moraines are well developed along the south side of the Avon in the upper part of the glen, but the most conspicuous example of this formation is to be seen along the course of the Allt Dearg, at the margin of the Map, one mile below the foot of Loch Avon. The corresponding moraine in the Larig na Laoigh, just outside this Sheet, is an equally fine specimen.

Another good example of a flat-topped and terraced lateral moraine flanks the north-west slopes of Carn Bheur and extends round the head of the corrie drained by the Faeshellach Burn to the foot of Carn Sheilg. The stream has cut a deep channel through the successive terraces that mark the different levels of the Strath Nethy glacier; and the sections show the nature of the rudely stratified, coarse, gravelly deposit that filled up the interval between the hillside and the shrinking ice.

A well-marked group of large moraines covers the ground between the river Gairn and the head of Loch Builg, and forms the southern barrier of that loch. Small lochans occupy the intervening hollows, and on the sides and tops of the moraines are large carried blocks of granite. A few well-formed conical moraines are seen at the head of Glen Builg, and others occur further down that glen, and on the left bank of the Avon immediately below Inchrory.

Peat.

Considerable deposits of basin peat occur in the Upper Cabrach, along the course of the Blackwater, at the head of the Don, in Glenlivet, Glen Dorback, and among the alluvial terraces of the Spey. The largest moss in the area is the Feith Musaich, near Tomintoul. It is more than a square mile in area, of great depth, and forms the chief source of supply for the village of Tomintoul and the Glenlivet distillery. Both here and in the mosses of Glenlivet the peat contains many roots and stems of *Pinus scoticus*, some of very large size. An interesting section is exposed in the banks of the Blackwater, 1½ miles above the Lodge. It shows 5 feet of brownish peat, resting upon a line of fir roots, beneath which follows 3 feet of black peat containing scattered twigs of birch. At the bottom is a layer of birch bark, which rests immediately upon the underlying boulder clay.

In addition to the valley peat-mosses, large tracts of country are covered with hill-peat. These have not been coloured in their entirety, but a marginal line of colour indicates the approximate boundaries of the deposit on the Map. The peat is generally confined to the higher part of the hills, and lies deep at the heads of the burns and over the cols, thinning out with bare interspaces along the summit ridges. It is most largely developed on the hills between the head of Strathavon and the Blackwater, along the county march of Banff and Aberdeen. Another large area of unbroken peat occurs north of Glenavon, round the upper waters of the Caiplich; and a third tract covers the summits of the Cromdale range.

Alluvium.

Owing to the hilly nature of the ground and the rapid fall of most of the streams, there are few extensive areas of alluvium in the area under consideration, though stripe of alluvial deposit, as shown on the Map, are found along the rivers and larger burns throughout the greater part of their course. Along the upper part of the Don, where the fall of the river above Cockbridge is very slight, there is a considerable stretch of alluvium; and the wide terrace, composed of fine sand and silt capped with sand and gravel, that lies above Inchmore may represent the extent of a former loch. The haughlands at Candacraig, lower down the river, probably also occupy the site of a loch, drained by the lowering of the rock-barrier at Pooldhulie.

In Glen Lochy, and along the lower course of the Avon, the terraces that indicate successive stages in the erosion of the narrow river valley are well marked, and as many as four of these can be traced at Inverlochy and Dalrachie.

The largest extent of high-level alluvium is found, however, in the small portion of Strathspey which crosses the N.W. corner of the Sheet. The Spey has here cut a channel through a wide sheet of gravel which rises in successive terraces on either side of the river to a height of nearly 200 feet above the present bed of the stream. The highest of these, especially on the west side, is much denuded, presenting

a series of ridges and hollows; while the gravel is often coarse and torrential in character, pointing to a possible fluvio-glacial origin for these early deposits.

The large area of alluvium seen in Glen Dorback at the edge of the Sheet, is in large measure of glacial origin, and has already been described under the head of sands and gravels.

V. ECONOMIC MINERALS.

Building-stone.—The Old Red Sandstone is quarried on a small scale near Tomintoul, and affords a good freestone, similar to the stone wrought at Quarry Hill near Rhynie in Aberdeenshire.

In the Cnoc Fergan quarries, on the west bank of the Avon at Dailbreac, the micaceous flagstones of the Cromdale Hills Series are largely wrought for paving-stones, etc., slabs measuring 6 feet and upwards in length being readily obtained. Black and grey slates of inferior quality are used locally for roofing purposes in several places.

Limestone.—The large development of limestone in Glenlivet, Strathavon, and Strathdon, affords an abundant supply of lime for agricultural purposes, but the highly crystalline and mineralised character of much of the rock detracts considerably from its value for burning.

Ores.—A vein of iron and manganese ore occurs in the black slate at the head of Glen Conglass, 4½ miles east of Tomintoul, and has been traced for nearly 3 miles from Coire Buidhe southwards over the Leachd Hill.

The iron ore is chiefly brown hæmatite, with a small quantity of the red variety. With it is associated a large quantity of brown hydrated oxide of manganese (psilomelane), and a little 'wad' or earthy black oxide of the same metal. The deposit occurs in a fissure—probably along a fault—whose sides are brecciated and very irregular. The iron was first wrought towards the end of the last century, and was smelted at Nethy Bridge. One hundred tons of the ore have yielded as much as 72 to 75 per cent. of iron. The manganese was worked for several years subsequently to 1841 by the Duke of Richmond and a Newcastle firm, who sunk the mine to a depth of 85 feet. The manganese ore was carried to Speymouth, a distance of 45 miles, and for the first few years brought £8 a ton, but on the price falling to £3, the mining was discontinued.

Plumbago.—A vein of soft brown graphite occurs in the gneiss on the east bank of the Allt Deveron below the farm of Bodiebae. Another locality for this mineral is at the head of the Carvie Water, 200 yards below the junction of the three head streams. A band of altered black shaly rock is here included in the diorite, and contains several veins of graphite from 1 to 4 inches in thickness.

Mineral wells.—A sulphureous well in the marshy flat known as the Feith Bhait, at the head of the Don, has a considerable local reputation for its medicinal properties. Wells to which peculiar virtues are attributed are also found on Cnoc Fergan and elsewhere in Strathavon; and there are chalybeate springs in many parts of the district, especially among the ferruginous black slates of Glenlivet.

Diatomaceous deposits.—Diatomite occurs in peat-mosses at Haugh of Milton and Auchnarran, on the south-east margin of the Map. It has been worked for some years at Black Moss and Ordie Moss in the adjoining Sheet to the east; and a full description of the various deposits, with a list of the *Diatomaceæ* collected from them will be found in the Explanation to Sheet 76 of the Geological Survey.

VI. GENERAL REMARKS ON THE PETROGRAPHY OF SHEET 75. By J. J. H. Teall, M.A., F.R.S.

The metamorphic rocks of sedimentary origin which form a large portion of the area included within this Sheet present many features of considerable interest from a petrographical point of view. The two rocks placed first in the following list differ markedly from the others as regards state of metamorphism. Clastic structures are still recognisable, and the only secondary mineral is sericitic mica. The rocks are merely cleaved fine-grained shaly sandstones. The other rocks have all suffered a considerable amount of change: clastic structures have been obliterated, new minerals have been developed, and the old minerals have in most cases changed their form either by enlargement or by recrystallisation. Notwithstanding the great amount of change which has taken place, the three principal types of sediment—argillaceous, arenaceous and calcareous—can in many cases be clearly recognised.

Argillaceous types are represented by garnet-biotite-schist, calc-biotite-schist and graphitic schist. A special feature of many of these rocks is the occurrence of large plates of mica, and sometimes also of a mineral probably belonging to the chloritoid group. These have been developed in the rock after a certain amount of interstitial movement had taken place, and frequently after all such movement had ceased. They lie at all angles with reference to the foliation; and when no movement has taken place since their development, the lines of opaque dust which mark the direction of foliation may be followed through the individuals without a break; but when, as sometimes happens, movement has taken place since their formation, the lines of inclusions in the minerals are not coincident in direction with those in the rock.

The arenaceous types of sediment are now represented by quartzites, mica-schists and granulitic gneisses. The rocks of the Cromdale Hills, which may be taken as illustrative of this group, are light-coloured, fine grained, and often banded or even laminated. Some are composed almost entirely of quartz with a few scattered flakes of white mica and now and then a grain of felspar (quartzites); others are mainly formed of white mica and quartz (mica-schists); others again of two micas, felspar, and quartz (granulitic gneisses). As accessory minerals we find zircon, rutile, sphene, ilmenite and occasionally garnet. The mutual relations of the principal constituents give no information as to the origin of the rock. The micas are for the most part flat plates with ragged edges, and one and the same plate may frequently be seen to penetrate two or more individuals of quartz or felspar. This point is one of some importance, as proving that the relations of the biotite to the other constituents cannot be used as a means of distinguishing the gneisses of sedimentary from those of igneous origin. As M. Michel Lévy has pointed out, the biotite of altered sedimentary rocks is very often allotriomorphic with respect to quartz and felspar; so that, unlike the biotite of typical igneous rocks, it forms a kind of paste in which the other constituents are embedded. But although this feature is very commonly recognisable, it cannot be employed as a diagnostic character in all cases; for the granulitic gneisses of the Cromdale Hills are unquestionably of sedimentary origin, and yet the biotite bears, in many cases, the same relation to the quartz and felspar as it does in the majority of igneous rocks. As still further destroying the diagnostic value of the feature in question, it may be mentioned that idiomorphism of the biotite is by no means a universal character of igneous gneisses.

Many of the rocks of the Cromdale Hills are true gneisses both in structure and composition, that is, they are foliated rocks essentially composed of quartz, orthoclase, oligoclase, and two micas. They are, however, more granulitic in structure than the undoubted igneous gneisses of similar composition. Although clastic structures are absent from the microscopic preparations there is one fact, observable under the microscope, which furnishes striking confirmation of the field evidence that the series, taken as a whole, is composed of metamorphosed sediments. Some of the more quartzose members show a fine banding or lamination, and the darker laminæ are rich in heavy minerals such as zircon, rutile and ilmenite. These minerals agree in form, size and mode of occurrence with those of the Hampstead Sands described by Mr Dick, and their presence is a convincing proof that the rock in which they occur must have been originally a fine grained sandstone deposited under conditions which admitted of the concentration of these minerals by current action along definite planes.

The calcareous varieties of sediment are represented in the collection by rocks belonging to the 'calc-silicate-hornfels' type. In addition to the carbonates, which are sometimes entirely absent, we find garnet, malacolite, green pyroxene, green hornblende, tremolite, idocrase and sphene. These minerals are not all found in any one rock, but they occur in different members of the group. A remarkable rock, somewhat doubtfully referred to this group, occurs at the head of the Blackwater (5443). It is a dark green slightly foliated rock, mainly composed of a granulitic aggregate of basic plagioclase, green pyroxene and sphene. Green hornblende, quartz and carbonate are also present. The specimen contains one large irregular patch of brown garnet enclosing rounded grains of pyroxene, and surrounded by a zone of pyroxene of a much deeper tint than that occurring in the main mass of the rock. Sphene is also very abundant in the neighbourhood of the garnet, and in one part of the slide forms a zone outside the pyroxene. The rock is therefore a pyroxene-granulite.

Amongst the metamorphic rocks from the area under consideration those which contain cordierite deserve more than a passing notice. They may be either massive (2965), gniessose (3811) or schistose (3809). The massive variety is well represented by a specimen from the top of the Buck of Cabrach (2965). This is a moderately coarse-grained, dark bluish rock spangled with small flakes of white mica. It possesses a somewhat spotted appearance, in consequence of the presence of irregular individuals or aggregates of cordierite. The colourless constituents make up the main mass of the rock. They consist of cordierite, andalusite, white mica, microcline, and quartz. The dark minerals are magnetite and biotite, but the latter mineral is very feebly represented. Cordierite, andalusite and white mica usually contain numerous inclusions of magnetite and quartz, and thus exhibit micropoikilitic structure (spongy contact-structure of Salomon *) in a striking manner.

Cordierite is very abundant, and its distribution can be readily observed in consequence of the yellow pleochroic halos, which are very numerous, and which, in the rocks under consideration, occur only in this mineral. The individuals show no trace of idiomorphism, and, as a rule, several occur together but without any definite optical relation to each other. The crystals and grains of magnetite, which are present as inclusions in the cordierite, are more numerous, but, on the average, of smaller size than those occurring in the other constituents.

* Ueber einige Einschlüsse metamorpher Gesteine im Tonalit. Neues Jahrbuch: Beilage Band VII. (1891).

White mica is also allotriomorphic, and occurs in aggregates of large individuals which mutually interfere with each other. Microcline is present in the form of a mosaic. The individuals are much smaller than those of the other principal constituents. Andalusite occurs sparingly, and is occasionally idiomorphic in the prismatic zone.

The rock from the south foot of Ben Avon (3811) resembles a true gneiss in appearance. Pink folia, mainly composed of quartz and alkali-felspar, alternate with others of a darker colour, rich in brown and white micas. Cordierite is far less abundant than in the specimen from the top of the Buck of Cabrach; quartz, felspar and biotite are, on the other hand, more abundant.

The third or schistose variety is represented by a specimen from the Linn of Avon (3809). It is a dark medium grained rock traversed by well marked planes of schistosity. The more schistose portions are separated by narrow bands of a granulitic character. The former are composed of quartz, felspar, two micas and iron ores, the latter of quartz, cordierite and felspar, with only a few flakes of mica and grains of ore.

In the three rocks above referred to, the cordierite is perfectly fresh, but in specimens from the top of Cairnbrallan (5441, 5442) which closely resemble in other respects the rock from the Buck of Cabrach, it has been almost entirely replaced by confusedly polarizing aggregates.

Cordierite-bearing rocks of metamorphic origin have received but little attention in this country, and it seems desirable, therefore, briefly to indicate what is known as to their distribution. Professor Bonney has described a rock of this type from a small mass, surrounded by sand, on the shore to the north of Aberdeen;* and cordierite has been recorded in contact-rocks from the Lake District by Messrs Hutchings and Harker.†

Very fine examples of cordierite-bearing rocks occur in Sheet 87, south-east of Little Arnage, about 2½ miles north-west of Ellon (2501, 3693), and also in a quarry north of Hilton, about 2½ miles north-north-west of the same town (3690, 3691 and 2512). These are dark, medium grained rocks with a peculiar bluish tint. Some appear perfectly massive in the hand specimen, but others show a decidedly gneissose structure. One specimen from the railway cutting south-east of Little Arnage (3693), is of considerable interest as throwing light on the origin of rocks of this type. It is evidently a compound rock due to the superposition of igneous upon metamorphic material. The igneous portion is represented by more or less idiomorphic oligoclase, biotite, micropoikilitic orthoclase and quartz; the metamorphic portion by cordierite, quartz, biotite, sillimanite, iron-ores and a green spinelle. The rock into which the granitic magma was intruded is now represented by somewhat ill-defined shreds, patches and streaks in a paste of igneous origin. Where such a rock occurs it is evident that the sharp junctions, so commonly observed between granite and the surrounding rock, cannot exist. An important question arises as to whether the disintegration may proceed so far as to isolate the individual constituents of the metamorphic rock and thus allow them to be scattered through the igneous magma. Such disintegration has been described by Professor Sollas in the case of the Carlingford gabbro, where it has been injected with granophyre, and Mr Harker has called attention to similar phenomena on a more extended scale in Skye. It is highly probable therefore that where granite is intruded into metamorphic rocks a similar action may occasionally

* Bonney, Prof. T. G., On Bastite-serpentine and Troktolite in Aberdeenshire, with a Note on the rock of the Black Dog. Geological Magazine, 1885, p. 439.

† Geological Magazine, 1894, pp. 65 and 169.

take place, and we may thus account for the occurrence of contact minerals, such as andalusite, cordierite and sillimanite in certain granites.

The rocks above referred to from the neighbourhood of Ellon are generally similar in structure and composition to those from Sheet 75, but they sometimes contain garnet and sillimanite in much greater abundance.

Cordierite-bearing rocks also occur at Hill Brae near the foot of Bennachie (2786) and at Kist Hill, east of Alford (2816, 2818) in Aberdeenshire; near the Rope Walk on the east side of Portsoy (2977) in Banffshire; and at Bennygray Hill (4864), Tolmount (4938), Glen Doll (4940), and Loch Esk (4939) in Forfarshire.

The cordierite-bearing rocks above referred to possess many points of resemblance to those described by Salomon* from the contact-zone surrounding the Tonalite of Monte Aviolo. In both cases we find cordierite, andalusite, quartz, felspars, white mica and biotite as essential constituents; and sillimanite, garnet, spinelle, tourmaline, iron-ores and zircon as accessory constituents. Of special interest is the occasional occurrence of a green spinelle both in the Scotch rocks and in those from Monte Aviolo. It was overlooked in the first instance and only found after a special search had been made for it in consequence of reading Salomon's paper. Corundum is also recorded by Salomon, but this mineral has not as yet been detected in the Scottish rocks. The resemblance between the Scottish and Italian rocks is, however, not limited to mineralogical composition; it extends also to the microscopic characters of the individuals and to their mode of association. Under these circumstances it is impossible to avoid the conclusion that the corresponding rocks in these two widely separated regions have been formed under similar chemical and physical conditions.

The igneous rocks from this Sheet range in composition from ultrabasic to acid. The ultrabasic and basic rocks are represented by serpentines, peridotites, gabbros, epidiorites, hornblende-schists and a peculiar variety of augite-diorite. Most of these rocks, if not all, were formed before the lateral stresses had ceased to operate on the district and, as a natural consequence, the massive rocks are intimately associated with schistose and foliated varieties. Intermediate and acid rocks are represented by quartz-diorites, biotite-granites, muscovite-biotite-granites or gneisses, microgranites, and felsites.

Comparatively unaltered peridotites are represented in the collection only by one specimen from Clachcurr Hill (6052). It is a black massive rock containing large irregular individuals of lustre-mottled (macropoikilitic) hornblende. The microscope reveals the presence of enstatite, olivine, serpentine, iron-ores and a green spinelle in addition to the hornblende. The rock may therefore be described as a hornblende-saxonite. Amongst the serpentines one from Braesashiel Farm (6058) has evidently been formed by the alteration of a massive olivine-enstatite-rock (saxonite) containing chromite or picotite. The classification and mapping of the basic rocks is attended with considerable difficulty in consequence of the gradual and frequent passages from augitic into hornblendic rocks and from massive to foliated structure. These passages have so frequently been described that any detailed reference to them is unnecessary. The first stage in the mineralogical change is marked by a peripheral modification of the augite or diallage and the development of a fringe of uralitic or actinolitic hornblende, the needles or fibres of which project

* Geologische und petrographische Studien am Monte Aviolo im italienischen Antheil der Adamellogruppe. Zeit. d. d. geol. Gesell., 1890, p. 450.

into the adjacent felspar. As the change proceeds the original pyroxene disappears and the felspars, which are free from inclusions of augite or hornblende in the comparatively unaltered rocks, become replaced by irregular patches enclosing needles and grains of hornblende. When foliation is developed the felspars are wholly or partially converted into granulitic aggregates and this change is often accompanied by unmistakeable evidence of cataclastic action.

The rocks to which the term epidiorite is applied are essentially composed of plagioclase and green hornblende; but the mutual relations of the constituents are unlike those of rocks directly formed from igneous fusion. They constitute a kind of intermediate stage between gabbro and dolerite on the one hand, and hornblende-schist on the other. The massive varieties gradually shade into augitic rocks with true igneous structure whilst the foliated varieties pass into hornblende-schists.*

Both gabbros and dolerites have contributed to the formation of the epidiorites and in some cases the dolerites were porphyritic owing to the presence of phenocrysts of felspar which have frequently become sanssuritised, with development of zoisite on epidote, during the change. Although by far the greater part of the hornblende in the rocks above referred to appears to be of secondary origin there is evidence that primary hornblende was present in some cases. Thus in a foliated rock from Pooldhulie Bridge (2804) there are large more or less rounded 'eyes' of a compact greenish-brown variety which was doubtless present in the original rock.

A remarkable rock of basic character occurs at the head of Allt Iomadaidh (4854). It is composed of numerous black crystals of hornblende, often measuring three-quarters of an inch across, set in a pale green, fine-grained groundmass. Under the microscope, the constituents are seen to be hornblende, pale green augite, plagioclase (often decomposed), biotite and sphene. The phenocrysts of hornblende, though often idiomorphic, are micropoikilitic in structure in consequence of the presence of biotite, augite and sphene as inclusions. The pale green augite occurs in small idiomorphic crystals. The most striking feature of the rock is the mode of occurrence of the felspar. It forms, as it were, the matrix and bears to the other constituents the same relation as the calcite of the Fontainbleau sandstone does to the grains of sand. Individuals measuring an inch or more across may be detected by observing the area over which definite reflections may be obtained from the fractured surface of the rock. Notwithstanding the large size of the individuals, the felspar forms only a small portion of the mass of the rock.

* The following is a list of a few of the papers and memoirs in which similar phenomena have been described :—

Bonney, T. G.—On the serpentine and associated rocks of the Lizard district. Q. J. G. S., xxxiii. (1877), p. 884.

Lehmann, J.—Die Entstehung der altkrystallinischen Schiefergesteine. Bonn, 1884.

Teall, J. J. H.—The metamorphosis of dolerite into hornblende-schist. Q. J. G. S., xli. (1885), p. 133.

——British Petrography. 1888. Plates xix. and xx. of this work illustrate the passage of dolerite into epidiorite and hornblende-schist. Fig. 1, plate xx., illustrates the typical structure of epidiorite.

Williams, G. H.—The gabbros and associated hornblende rocks occurring in the neighbourhood of Baltimore. Bull. U. S. Geol. Survey, No. 28. Washington, 1886.

Teall, J. J. H.—The metamorphosis of the Lizard gabbros. Geol. Mag., 1886, p. 481.

Bonney, T. G. and M'Mahon, C. A.—Results of an examination of the crystalline rocks of the Lizard district. Q. J. G. S., vol. xlvii. (1891), p. 464.

Hornblende and augite are the two principal constituents, and are so thickly crowded together as frequently to reduce the felspar in the thin section to detached angular patches.

A rock closely allied to the one above described, occurs as a dyke in the Lewisian gneiss in the Allt-a-Mhullin, south of Loch Inver. The structures of both rocks are the same; but in the Sutherland specimen the felspar is fresh (oligoclase-andesine), and the augite has been replaced by secondary green hornblende, whereas, in the rock just described, the felspar has been more or less decomposed, whilst the augite has retained its original character. The specific gravity of the former is 3·05; that of the latter 2·96; both are therefore basic rocks.

The intermediate rocks are represented by quartz-biotite-diorites of which the specimen from Bealach Dearg (3817) may be taken as an example. This is a granitic rock identical in structure and composition with a common variety of the Dalbeattie granite.*

It is composed of zoned, idiomorphic plagioclase, biotite and hornblende with interstitial quartz and alkali-felspar. Sphene and iron-ores occur as accessories. In the majority of specimens belonging to this type the hornblende is undoubtedly original; but in one or two it is in part uralitic and in one specimen a grain of pale coloured augite has escaped uralitization. This occurrence of augite is another point of resemblance between these rocks and those of the Dalbeattie mass.

The acid igneous rocks with the exception of a remarkable spherulitic felsite from Meikle Fergie Burn (3815) are sufficiently described in the appended list. This rock consists of brick-red spots thickly crowded together in a light coloured slightly reddish matrix. In some portions of the specimen the spots have coalesced into thin red bands which run parallel, or nearly so, to one another. When examined with a hand-lens the kernel of each spot is seen to consist of a compact brownish, chert-like spherule; the brick-red material forming a zone round the kernel. The boundary between the kernel and the brick-red zone is sharp; that between this zone and the matrix is less distinctly marked.

A thin chip of the rock when heated in the blowpipe fuses and froths up so as to form a white pumiceous substance. The kernels evidently contain the bulk of the volatile matter.

Under the microscope these kernels are seen to be colourless with pale yellowish brown patches. They show indistinct polarization with a faint approach to radial structure in places but no definite black cross. The aureoles surrounding the kernels are stained a deep red colour, the intensity of which decreases outwards. The interspaces between the compound spherulites are sometimes occupied by nearly colourless cryptocrystalline matter and sometimes by a brownish, minutely spherulitic, substance. These small spherulites give a fairly well defined positive black cross.

An analysis of this rock has kindly been made for us by Mr J. Hort Player.

Silica,	68·3
Alumina,	12·6
Ferric oxide,	1·1
Ferrous oxide,	·3
Lime,	1·8
Magnesia,	·7
Soda,	·5
Potash,	5·9
Loss on ignition,	9·0
	100·2

* See Explanation to Sheet 5.

The analysis proves the rock to be a potash-felsite with an extraordinary amount of volatile matter. In its behaviour before the blow-pipe the rock resembles the mica-dacite-glass from Fifeshire described by Mr Durham and Professor Judd,* and the globules of glass from Siberia which are known under the name of marekanite.† There can be little doubt that the kernels of the spherules above described are substantially identical with the globules of marekanite.

* Q. J. G. S., vol. xlii. (1886), p. 418.

† Judd, Prof. J. W., On Marekanite and its allies. Geological Magazine, 1886, p. 241.

APPENDIX.

A. List of Rocks and Microscopic Sections from Sheet 75, in the Collection of the Geological Survey.

Metamorphic Rocks of Sedimentary and Doubtful Origin.

Rocks.	Locality.	Remarks.
Shaly Sandstone. (2967)	Head of Allt Slochd Mòr.	Cleaved. Clastic quartz, felspar and mica. Secondary sericitic mica.
Do. (2968)	Same locality.	Original lamination much disturbed by movement. These two rocks are far less altered than any of the others; no signs of thermo-metamorphism.
Garnet-biotite-schist. (3435)	Ailnack Gorge, Strathavon.	Lead coloured and carbonaceous. Conspicuous idiomorphic garnets. Biotite in large plates of late date.
Calc-biotite-schist. (3436)	Same locality.	Large irregular plates of secondary biotite with inclusions.
Graphitic schist. (3816)	Bridge of Livet.	White mica (secondary) in conspicuous plates often lying across foliation.
Mica-schist. (2248)	Bridge of Brown; between Tomintoul and Grantown.	Two micas and quartz.
Quartz-schist. (4842)	North slope of Cromdale Hills.	Felspathic, with white mica.
Mica-schist.	Top of Cromdale Hills.	
Quartzite. (4844)	Cromdale Hills.	Laminated; dark laminæ rich in ilmenite, zircon and rutile. Original rock a fine grained felspathic sandstone.
Granulitic gneiss. (4845)	S. E. face of Cromdale Hills above Glen Lochy.	Quartz, felspar (oligoclase and orthoclase) two micas, ilmenite and zircon.
Do. (4846)	Same locality.	
Do. (4847)	Aultcharn, Cromdale.	Biotite only; garnet, sphene, zircon, and iron-ores.

Rocks.	Locality.	Remarks.
Muscovite-biotite-gneiss. (4848)	Slack north of Ballenluig, Cromdale.	Felspars and micas very abundant; granulitic structures less marked than in other rocks from the Cromdale Hills.
Granulitic gneiss. (4853)	Water of Livet, between Poolwick and Dregnie Burn.	Two micas; biotite predominates and is often allotriomorphic with respect to quartz and felspar.
Mica-schist. (5448)	Creag na Cadha, Glen Loin, Glen Avon Forest.	
Quartz-felspar-rock. (5450)	Glen Avon.	Zircon as accessory. Altered felspathic sandstone.
Do. (5452)	Same locality.	
Do. (5453)	Little Loin Burn, Glen Avon.	Biotite and chlorite.
Granulitic gneiss. (5455)	Head of Caiplich Water, Banff.	Laminated and flaggy.
Quartz-schist. (6063)	Head of Conglass Water.	Sericitic mica and magnetite.
Calcite - garnet-pyroxene-rock. (2006)	Glen Gairn, N. W. of Ballater.	Green pyroxene.
Malacolite-hornfels. (3437)	Limestone quarry, Mammie Hill, Glen-Gairn.	Greenish, compact banded rock. Dark bands contain hornblende.
Garnet-malacolite-idocrase rock. (3812)	Wester Kirn Burn, Glen Gairn.	Felspar, carbonates, and hornblende also present.
Tremolite-schist. (5245)	1st tributary on north side of Allt Dearcaige.	
Garnet-pyroxene-hornblende-sphene-plagioclase-rock. (5443)	Head of Blackwater.	Large patch of micropoikilitic brown garnet, zoned with deep green augite and sphene; granulitic basic plagioclase.
Pyroxene-hornblende-granulite. (5444)	Stroninch, Blackwater Forest.	Contains alkali-felspar and a colourless mosaic; also iron-ores and sphene as accessories.
Malacolite-hornfels (?) (5449)	Glen Loin, Glen Avon Forest.	Micropoikilitic malacolite in fine grained aggregate of quartz, felspar, biotite, chlorite, and carbonates.
Malacolite-tremolite rock. (5454)	Inchrory, Glen Avon, ¼ mile below Linn.	Granulitic plagioclase (? anorthite).
Tremolite-schist. (5456)	Allt Dubh, Inchrory.	Granulitic quartz and felspar in lenticular folia.
Malacolite-rock. (6062)	⅛ mile below head stream of Conrie Water, Strathdon.	Granulitic malacolite.

Rocks.	Locality.	Remarks.
Cordierite-gneiss. (2965)	Top of the Buck of Cabrach.	Cordierite, microcline, quartz, andalusite, two micas, magnetite, tourmaline.
Do. (3809)	Linn of Avon.	Somewhat flaggy and schistose.
Do. (3810)	Same locality.	
Do. (3811)	Slopes of Ben Avon.	True gneiss in appearance; pink folia.
Do. (altered) (5441, 5442)	Top of Cairnbrallan.	Resembles 2965. Sillimanite and altered cordierite.
Calc-hornblende-schist. (5445)	Mheoir Bheannaich, Inchmore, Corgarff.	Large individuals of micropoikilitic hornblende; colourless felspar-mosaic.
Do. (5446)	Same locality.	
Hornblende-biotite-rock. (5457)	Little Geal Carn.	Quartz scarce; idiomorphic rutile abundant.
Andalusite-schist. (2966)	Scad Hill, Lumsden.	Micropoikilitic andalusite abundant; interspaces filled with granulitic quartz and biotite.
Sillimanite-biotite-gneiss. (5244)	Rhynetrick Burn.	Granulitic; biotite often allotriomorphic.
Sillimanite-biotite-gneiss. (6051)	Greenstile, Strathdon.	Moiré-orthoclase; oligoclase, quartz (in part vermicular).
(?) (6056)	Burn, S.S.E. corner of Socach Wood, Conrie Water.	Minute lenticular folia of quartz in a dark blue microcrystalline matrix; epidote and much black dust—probably carbonaceous.
Quartz-hornblende-schist. (6061)	Meikle Fergie Burn; River Avon near Torbain.	Large individuals of micropoikilitic hornblende; quartz mosaic; some calcite and biotite; also tourmaline. Specimen contains a light patch of acid igneous rock (biotite-granite ?).
Chlorite-felspar-schist. (6060)	Head of Allt a Choilich, 3 miles S. of Cock Bridge, Corgarff.	
Calc-hornblende-rock. (2806)	Wood above Balneaden.	(?) Altered ultra-basic rock.

Igneous rocks.

Serpentine. (1769)	Blackwater Lodge, S.E. of Dufftown.	
Do. (1770)	Same locality.	Schistose.

Rocks.	Locality.	Remarks.
Hornblende-peridotite. (6052)	Clachcurr Hill, Strathdon.	Large individuals of luatre-mottled hornblende. Enstatite, olivine, hornblende, serpentine, iron-ores, and a green spinelle.
Serpentine. (6058)	Braesashiel Farm, Glen Ernan.	Altered saxonite with chromite or picotite.
Do. (6059)	North slope of Breagach Hill, Strathdon.	
Gabbro. (2963)	Blackwater, 1 mile north of Lodge, Banff.	Partially uralitized.
Do. (2964)	Foot of Craig-na-cloich Burn, Blackwater.	Partially uralitized; traces of cataclastic action on the felspars.
Olivine-gabbro. (2805)	Pooldhulie Bridge, Strathdon.	Peripheral uralitization of the diallage, foliated.
Foliated gabbro or basic diorite. (2804)	Same locality.	Dark rock with strongly marked 'augen' and 'flaser' atructurea. Microcrystalline felspar. No augite remaining. Hornblende in part original.
Uralitized gabbro. (2810)	Wood above Castle Newe, Strathdon.	Felspars partially sanssuritized; rock almoat an epidiorite.
Epidiorite. (2809)	Nochty Burn, ¼ mile E. of Righorach.	Porphyritic felspars sanssuritized.
Do. (2812)	Deskry Water and slopes of Morven.	Similar to 'gabbro-diorite' of Williams (Bull. U. S. Geological Survey, No. 28, 1886).
Do. (2971)	Conrie Water, under Socach Wood.	
Do. (2972)	Head of Conrie Water.	
Hornblende-achist and achiatoee epidiorite. (3278)	Allt Garbh Choire, Glen Lary.	
Schistoee epidiorite. (2803)	Glen Bucket, 200 yards below lodge.	
Gabbro-schist. (2811)	Glen Conrie, Birkford, Strathdon.	Banded roch composed of more or less crushed felspar and hornblende.
Schistose-epidiorite or hornblende-schist. (5242)	Allt Cattanach.	
Epidiorite. (5243)	Rhynetrick Burn.	
Do. (5447)	Stroninch, Blackwater Forest..	
Do. (?) (6050)	Near head of Allt Daveron, Glen Bucket.	

Rocks.		Locality.	Remarks.
Epidiorite (?)	(6055)	Burn 250 yards S. of Belnagaul, Glen Carvie.	With flaser structure, probably altered gabbro.
Do.	(6057)	Allt Slochd Chaimbeil, Glen Nochty.	Porphyritic, traces of igneous structure, felspars partially saussuritized with development of zoisite and epidote.
Do.	(6064)	River Don at Culfork, Inverernan.	Schistose.
Quartz-biotite-diorite.	(3813)	Slope of Cairn Tiekiever.	Hornblende uralitic, original rock probably a quartz-augite-biotite-diorite.
Do.	(3817)	Bealach Dearg, top of Coul, Glen Gairn.	Interstitial quartz and microcline, sphene.
Do.	(3818)	S.E. slope of Culardoch, Glen Gairn.	Interstitial quartz and orthoclase.
Do.	(4855)	Head of Allt Iomadaidh, Braes of Abernethy.	Augite core in hornblende.
Do.	(6047)	Top of Beinn Newe, Glenbucket, Strathdon.	Zoned plagioclase, interstitial quartz, apatite, sphene, and ores.
Do.	(6048)	Side of track, ¼ mile S.E. of Meikle Forbridge Hill, Glenbucket.	
Do.	(6053)	Dockington, Glenbucket.	Hornblende ophitic and micropoikilitic.
Diorite (?)	(6054)	400 yards S.W. of Kirkton of Glenbucket.	Granulitic plagioclase and a pale coloured hornblende.
Augite-diorite.	(4854)	Letterauchten, Head of Allt Iomadaidh, Braes of Abernethy.	Malacolite; micropoikilitic hornblende and felspar.
Biotite-gneiss.	(2969)	Spearach Burn, Glen Ernan.	Flaser structure well marked, phacoids of microcline, secondary mosaic due to granulitization of felspar.
Muscovite-biotite-gneiss.	(2970)	Ernanside, above Edinglassie.	Microcline with inclusions of oligoclase and quartz, vermicular quartz. Cairnshee type (see Annual Report of the Geol. Survey for 1895, p. 23).
Biotite-granite.	(5247)	Strathavon.	Oligoclase, microperthitic microcline, quartz and biotite.
Do.	(5458)	Glen Avon, N. of the Bruach Cairn.	Idiomorphic oligoclase and biotite with interstitial quartz and moiré-orthoclase or microcline, sphene and apatite.

Rocks.	Locality.	Remarks.
Biotite-granite. (5460)	Top of Ben Macdhui.	Idiomorphic oligoclase and biotite with interstitial quartz and moiré-orthoclase or microcline, sphene and apatite.
Do. (6049)	A few yards W.S.W. of Lochery, Glenkindie.	Microcline abundant, vermicular quartz.
Micro-granite. (5246)	Kymah Burn, Glen Livet.	Phenocrysts of oligoclase, microperthitic orthoclase and biotite in a microcrystalline groundmass.
Spherulitic felsite. (3815)	Meikle Fergie Burn, Strathavon.	
Oligoclase-hornblende-porphyrite. (3814)	Little Allt Beithachan, W. of Strathavon.	Phenocrysts of oligoclase and hornblende in a micro-crystalline matrix; biotite scarce.

B. List of Publications.

RELATING TO THE GEOLOGY OF THE DISTRICT INCLUDED IN SHEET 75.

1840. Geological Map of Scotland. John Macculloch, F.R.S.

1843. 'The Geognosy of Banffshire,' by R. J. H. Cunningham; *Trans. Highland Society*, vol. xiv.

1859. 'On the Geological Structure of the Vicinity of Aberdeen and the N.E. of Scotland,' by James Nicol; *Brit. Ass. Rep.*, 1859, and *Edin. New Philosophical Journal*, New Series, vol. xi. p. 126.

1859. 'On the Drift Beds and Boulders of the North of Scotland,' by Mr T. F. Jamieson; *Brit. Ass. Rep.*, 1859.

1860. 'On the Drift and Rolled Gravel of the North of Scotland,' by Mr T. F. Jamieson; *Quart. Jour. Geol. Soc.*, vol. xvi. p. 347.

1866. 'Geology of the North of Scotland,' by Professor Nicol.

1878. 'The Old Red Sandstone of Western Europe,' by Arch. Geikie, LL.D., F.R.S.; *Trans. Roy. Soc., Edin.*, vol. xxviii. p. 345 [contains a description of the Old Red Sandstone outlier at Tomintoul].

1879. 'Chapters on the Mineralogy of Scotland,' by Professor M. F. Heddle; *Trans. Roy. Soc., Edin.*, vol. xxviii. pp. 197, 299, and 453.

1880. 'Chapters on the Mineralogy of Scotland,' by Professor M. F. Heddle; *Trans. Roy. Soc., Edin.*, vol. xxix. pp. 1, 55.

1883. 'Chapters on the Mineralogy of Scotland,' by Professor M. F. Heddle; *Trans. Roy. Soc., Edin.*, vol. xxx. p. 427.

[These papers of Professor Heddle contain many references to mineral localities within the Sheet, as well as several analyses of new and rare minerals from Tomintoul, Glenbucket, Strathdon, and Glengairn.]

1891. 'Wanderings in the Highlands,' by J. C. Phillips.

LIST OF PUBLICATIONS

OF THE

GEOLOGICAL SURVEY OF SCOTLAND.

I.—Maps on One-inch Scale.

1. Wigtownshire, Southern Districts. 4*s.*
2. Wigtownshire, South-Eastern Districts. 4*s.*
3. Wigtownshire, South-Western Districts. 6*s.*
4. Wigtownshire, East Park: Kirkcudbright, portion of W. Division. 6*s.*
5. Kirkcudbrightshire, Southern Districts. 6*s.*
6. Kirkcudbrightshire, S.E.; Dumfriesshire, S. margin. 4*s.*
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76. Aberdeenshire, Kincardineshire. 6*s.*
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95. Elginshire. 4*s.*
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97. Aberdeenshire and Eastern Banffshire. 4*s.*
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,,	Sheets 7, 8, 11, 12, 15. 1[illegible]
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,, 5. Ayrshire Coal-fields (east side).
,, 6. Renfrewshire and Dumbartonshire.
,, 7. Cheviot and Lammermoor Hills.
,, 8. Clyde Coal-field and Campsie Hills.
,, 9. Ayrshire Coal-fields (Muirkirk and New Cumnock).

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,, 3. Kilmarnock Coal-field.
,, 4. Clyde Basin Coal-field.
,, 5. Stirling and Clackmannan Coal-fields.
,, 6. Muirkirk, Lesmahagow, and Douglas Coal-fields.
,, 7. Lanarkshire Coal-fields (Rutherglen and Carluke).

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SCOTLAND.

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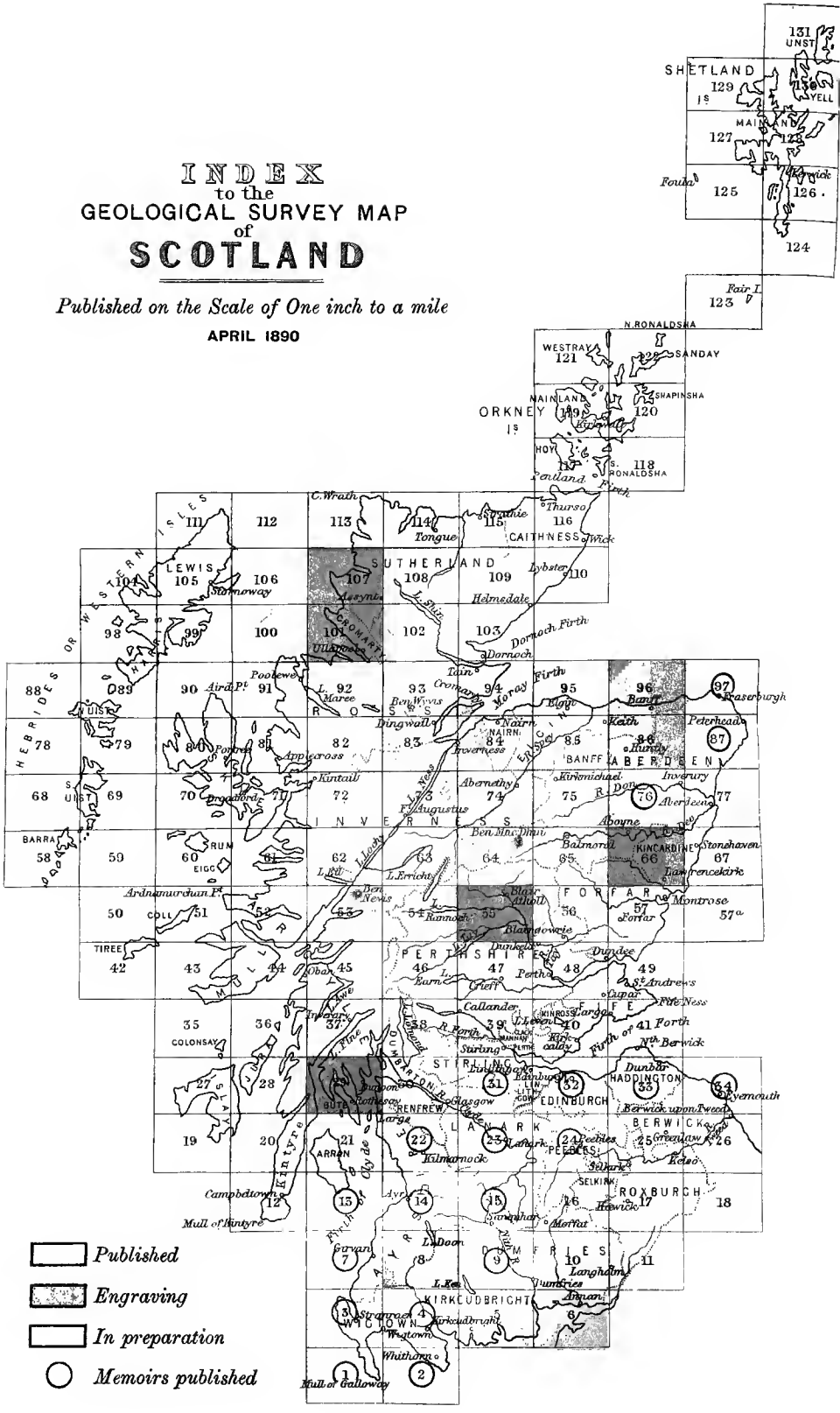
INDEX
to the
GEOLOGICAL SURVEY MAP
of
SCOTLAND
Published on the Scale of One inch to a mile
APRIL 1890
SHETLAND
ORKNEY
HEBRIDES OR WESTERN ISLES
SUTHERLAND
CAITHNESS
LEWIS
INVERNESS
ROSS
NAIRN
BANFF
ABERDEEN
KINCARDINE
FORFAR
PERTHSHIRE
STIRLING
EDINBURGH
HADDINGTON
BERWICK
ROXBURGH
SELKIRK
PEEBLES
LANARK
RENFREW
BUTE
ARRAN
DUMBARTON
WIGTOWN
KIRKCUDBRIGHT
DUMFRIES
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In preparation
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0 5 10 20 30 40 50 60 70 80 90 100 Miles

Memoirs of the Geological Survey,

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PREFACE.

THE Sheet of the Geological Survey Map, of which the present Explanation contains a description, was surveyed geologically by Messrs J. Horne, H. Skae, D. R. Irvine, J. S. Grant Wilson, and L. W. Hinxman. Mr Horne's portion was confined to an area of only a few square miles north of the Kirktown of Clatt, which was connected with his work in the Sheet to the north (86). The late Mr Skae mapped most of the southern part of the Sheet south of a line drawn from Baderonach Hill on the west to Loch Skene on the east. Mr Irvine's share embraced a narrow strip along the eastern margin of the map, but extended in the Kintore district as far west as Kemnay. Mr Wilson took the basin of the River Don from about Invermossat eastward to the boundary of Mr Irvine's ground. Mr Hinxman completed the rest of the Sheet to the west and north.

Owing to the death of Mr Skae, and the retirement of Mr Irvine from the service, the task of preparing the present Explanation was entrusted to Messrs Wilson and Hinxman. They have traversed the parts of the district not surveyed by themselves, and their descriptions of these have been prepared partly from their own notes and partly from those of their colleagues who originally mapped that ground. Mr Wilson has written paragraphs 8–10, 23–26, 29, 30, 32–34, 37, 67, 68, 71, 75–79, 81, 83–88; Mr Hinxman has supplied paragraphs 1–7, 11–22, 27, 28, 31, 35, 36, 38–66, 69, 70, 72–74, 80, 82.

The detailed petrographical examination of the various rocks described in the following pages has been performed at the Jermyn Street office of the Geological Survey, chiefly by Mr J. J. H. Teall, partly by Dr F. H. Hatch. These gentlemen have from time to time supplied to the officers in the field the results of their microscopic investigation of the rocks sent up to them during the progress of the field-work, and these results are embodied in the text. In Appendix I. a list is given of the rocks so examined, and of the localities from which they were collected.

ARCH. GEIKIE,
Director General.

GEOLOGICAL SURVEY OFFICE,
28 JERMYN ST., LONDON, 14*th February* 1890.

EXPLANATION OF SHEET 76.

I. AREA INCLUDED IN THE MAP.

1. This Sheet of the Geological Survey of Scotland represents 432 square miles of ground lying wholly within the County of Aberdeen, with the exception of a small part of Kincardine, about 9 square miles in extent, included in the S.E. corner of the Map. This area extends eastwards from the hills that form the watershed between the Don and the Deveron, to the low undulating country about Inverurie and Kintore, and from Kennethmont, Insch, and Old Meldrum on the north, southwards nearly to Deeside. It thus includes the eastern half of the ancient division of Mar, the lower part of the Garioch, and the southern limits of Strathbogie.

II. PHYSICAL FEATURES OF THE COUNTRY.

2. The greater part of the area embraced in this Sheet is hilly, especially in the west and central portions. To the north, the smooth heather-covered range of the Correen Hills extends for some 10 miles from the edge of the Old Red Sandstone basin at Lumsden in an easterly direction; the trend of the hills being roughly parallel to the strike of the schists and slates of which they are composed. The range is further continued in, and terminated by, the granite mass of Bennachie; the col, over which passes the high road between Insch and Alford, forming approximately the boundary between the schists and the granite.

Bennachie, the most conspicuous hill in this part of Aberdeenshire, rises boldly from the low ground on the N. and E. and sweeps upwards in numerous bold and craggy peaks, produced by the tabular weathering of the coarse granite. The highest of these, the Oxen Craig, reaches an elevation of 1730 feet above the sea: the more picturesque "Mither Tap," girdled with its ancient fort of rough piled stones, not exceeding 1698 feet.

Along the N.W. margin of the Map, and separated from the Correen Hills by the Old Red Sandstone basin, extend the lower spurs of the hills which occupy the country between the upper Deveron and Donside, their flanks generally clothed with fir and larch plantations, their summits heather-covered or bare and stony.

Another important range enters the Sheet a little to the south of the Don, and extends eastwards to the Corrennie Forest, where it bifurcates, one ridge running to the north to form the Green Hill, and the granite

mass of Cairnwilliam, while the southern branch terminates in the Hill of Fare, just within the boundary of Kincardine. These hills, composed entirely of gneiss and granite, are for the most part treeless and heather-clad, and include the highest ground in the Map, Broom Hill and the Sockaugh reaching the heights of 1883 and 2032 feet respectively.

The Coillebharr Hills form another isolated group, in reality part of the Correen range, but separated from it by the deep valley of the Don.

To the N. and E. of the Correen Hills and Bennachie, lies a tract of undulating country, falling gradually towards the S.E., and characterised by isolated bossy hills of gneiss and diorite. Thickly covered with drift, this district is in a state of high cultivation, and contrasts favourably with the barren moorlands of the west.

3. *River Valleys.*—The main river system is that of the Don, which, with its tributaries the Mossat, Leochel Water and Ury—the latter including the Gady, Shevock and Lochter Burn—drains the greater part of the area under consideration.

The Don enters the Map at Towie, and flows in an easterly direction nearly across the centre of the Sheet to Inverurie, where it is joined by the Ury, and bending at right angles takes the course of its tributary and flows nearly due S. to Kintore. Above Inverurie the valley of the Don, with the exception of the alluvial basin forming the vale of Alford, is for the most part narrow and trench-like, while that of the Ury and its tributaries is broad in proportion to the present volume of the stream. This fact, together with the dominant course of the latter at Inverurie, suggests the possibility that the course of the Don may have been at one time to the north of Bennachie and the Correen Hills, or at any rate that the Ury was once the more important stream.

The N.W. corner of this area is drained by the upper waters of the Bogie and its tributaries, which, flowing over the Old Red Sandstone basin, have cut deep and romantic ravines through the softer members of that formation.

To the south of the hills which form the watershed between Dee and Don, there are no streams of any importance. The only natural sheets of water are Loch Skene in the S.E., a shallow lake of some 500 acres in extent, resting on boulder-clay and surrounded by peat mosses; and in the extreme S.W. Loch Davan, a smaller loch of the same character.

III. FORMATIONS AND GROUPS OF ROCKS ENTERING INTO THE GEOLOGICAL STRUCTURE OF THE DISTRICTS.

[Sedimentary Rocks.

				Signs on Map.
Post-Tertiary,	Recent.	Alluvium,	Fresh-water.	
		Peat,	Subaerial.	
	Glacial Deposits.	Erratic Blocks.		
		Moraines.		
		Sands and Gravel.		
		Boulder-Clay.		
Lower Old Red Sandstone,		Dryden Flags and Shales.		
		Quarryhill Sandstones.		
		Tillybrachty Sandstones.		
		Lower Red Shales with Calcareous bands.		c^1
		Basal Breccia and Conglomerate.		

Crystalline Rocks.

Schists.

		Signs on Map.
Age not yet satisfactorily determined, but probably including Metamorphosed Silurian Rocks,	Mica Schist,	g
	Knotted and Andalusite-Schist with Clay-Slate bands,	i^3 i^2
	Quartzite and Quartz-Schist,	l
	Gneiss,	x a^4
In any Zone of this Schistose Series,	Limestone,	λ
	Serpentine,	s

Igneous and Volcanic.

Interbedded.

Lower Old Red Sandstone,	Porphyrite,	PoC^1

Intrusive.

Do.	Do.	Basalt and Dolerite,	B
Associated with the Schistose Series,	Granite,	In Dykes and Masses,	G
	Quartz-Porphyry,		E
	Felstone,		F
	Syenite,		S
	Diorite,—including Augite-Diorite, Mica-Diorite, and Gabbro,		Gn

IV. GEOLOGICAL STRUCTURE OF THE DISTRICT EMBRACED IN THE MAP.

4. The whole area of this Sheet, with the exception of a narrow belt of Old Red Sandstone near the N.W. margin, is occupied by metamorphic and igneous rocks. The schists and gneiss form the hills which lie to the north and the south of the vale of Alford and the upper valley of the Don; the gneiss also occupying the low ground about Inverurie. The granite covers a wide area extending from Bennachie in the north to the southern margin of the Map, and reaching westwards as far as Tarland; while on the north the diorite and gabbro form a band which bounds the Sheet, narrowing towards Old Meldrum, and interrupted in the west by the Old Red Sandstone basin.

Crystalline Schists.

(1) Gneiss.

5. A glance at the Map will show that the gneiss occupies two well-marked areas on either side of the Don, in the N.E. and S.W. portions of the Sheet. These areas are nearly connected by the band of gneiss crossing the Don at Monymusk, but are cut off from each other by the narrow neck of granite which bounds the Howe of Alford on the

east, and forms the hill of Tillyfourie. In connection with the southern area, is the small district occupied by this rock on the northern bank of the Don at Towie, where it lies beneath the southern extremity of the Old Red Sandstone basin, and forms its western boundary as far as Longley.

The areas under consideration may be regarded as the south-western extension of that broad tract of gneiss that has been found to extend from the eastern sea-board near Fraserburgh through Sheets 97, 87, and 86; and of which a description will be found in the published explanations accompanying the two former of those Sheets.

6. *Inverurie.*—The gneiss of this district to the N. of the river Don, is usually a dark, fine-grained micaceous rock, mostly well foliated, and becoming schistose about Braco and Chapel of Garioch. Owing to the thick covering of boulder-clay, the country about Inverurie affords few natural sections, but the rock can be seen in small quarries at Ardtannes, Dilly Hill, and east of the Ury about Portstown, Boynds, and Souterford. The planes of foliation are usually inclined to the W. of N. at an angle of from 40° to 60°

On the north bank of the Don, at the bend immediately below the ruined chapel of St Apolinarius, and nearly opposite the farm of Woodend, there occurs a gneiss of a different character. It is a very coarse, gnarled granitoid rock, with the folia often considerably crumpled, and contains numerous strings and lumps of infiltrated quartz. A similar rock is found about a mile higher up, on the S. bank of the stream.

The gneiss of Dilly Hill contains a good deal of hornblende, and at Old Balquhain, a little to the W., this mineral increases in amount, the foliation becomes more or less indistinct, and the rock assumes the character of a foliated diorite, finally passing into the porphyritic diorite which forms the summit of Knockinglew Hill just above.

East of the river Ury the gneiss is exposed in a few places about Harlaw and Lethenty, and between Brupter and Bourtie, and is of the usual fine-grained micaceous variety, though sometimes it becomes hornblendic. Close to the boundary of the gneiss, immediately to the N. of Kirkton of Bourtie, the rocks are thrown into a synclinal fold, and at Hawk Law can be seen dipping to the S.S.E. at an angle of 50°.

The junction of the gneiss with the granite along the eastern and northern flanks of Bennachie is invariably obscured by drift and hill-wash. In the few places where the former rock is exposed near the boundary, as at Hillbrae S. of Oyne, and Dorlethen, it is coarse and very granitoid in appearance. A specimen from Hillbrae was found under the microscope to consist of quartz in elongated grains, associated with a large quantity of biotite, good crystals of felspar, muscovite, patches of magnetite, and crowds of acicular microliths of sillimanite. It is probable that there is here a graduated passage from the one rock into the other, and that the gneiss at this point may be regarded as a sheared granite, forming part of a belt of foliated rock that flanks the granite mass of Bennachie on the east.

7. *Clova Hills.*—On the north of the Don, at the western edge of the Map, the gneiss underlies the knotted schist series, dipping to the N.E. and E.N.E. at angles of 40° to 50°. The boundary line drawn over the wooded hills on the W. of Kildrummy Castle is conjectural, and the presence of incipient knots and aggregations in the gneiss at Sauchenbog, where the rock is well exposed in a deep wooded ravine, points to a gradual passage into the schists above. Four miles to the north of this point, a band of gneiss or gneissose mica-schist extends from Todstown, under Tombhreac Hill, to the margin of the Sheet. The dip is to the E. of N.,

and the rock appears to overlie the knotted schists of Clova Hill, and is probably only a locally developed band in that series. It is well seen in the crags on Clayhooter Hill, and is there a gnarled and contorted gneissose rock, in which elliptical aggregations of black mica are surrounded by irregular layers of quartz and felspar. Under the microscope it appears as an aggregate of biotite, quartz, andalusite, plagioclase, and muscovite. The grains of andalusite are somewhat isolated, they are full of inclusions, and show faint pleochroism. Grains of magnetite are also present. A higher power reveals sillimanite, in crowds of acicular microliths, disposed in diverging bundles.

8. *Leochel and Cushnie.*—The gneiss area to the south of the Howe of Alford occupies the portion of the Map that lies between the Corrennie Forest and the river Don. The general inclination of the foliation planes is to the north, and as a result of this uniformity of dip, the line that separates the gneiss from the knotted schists runs east and west. Below Mill of Brux, on the Don, gneiss with bands of knotted schist is found inclined at a high angle. At this point these bands form passage beds between the gneiss and knotted schists. From the mill the divisional line that marks the northern extension of the gneiss curves gently round the foot of the Cotter, and runs eastwards by the base of the Langgadlie Hill as far as Bridge of Inver. The Leochel Water is here joined to the Cushnie burn, and although this stream runs for the greater part of its course along a deep and narrow valley, it gives but few rock-sections. Where seen, the gneiss is generally a coarse grey massive rock, very micaceous, with finer schist-bands and sometimes garnetiferous. So coarse does this rock become in some exposures as almost to pass into a fine-grained granite. From Inver to opposite Droichbridge a fault evidently forms the boundary line, separating the gneiss and granite from the knotted schists. To the north of this mass of granite the limit of the gneiss is marked by a line passing round Strone Hill, and from this point with a S.E. trend it abuts against the granite near the Church of Tough. The Leochel Water, as far as it runs through this portion of the gneiss area, affords only a few isolated rock exposures. On the top of the Foulis and Carnaveron Hills the foliation planes of this zone are found to be inclined to the west and north-west at high angles. In the Tough district the northern slopes of the Corrennie Forest are comparatively bare of drift, and over this portion the foliation planes of the gneiss are generally inclined to the north and north-west at an average angle of 40°.

9. *Corrennie Forest.*—This ridge of high ground is situated to the south of Alford, and there forms the watershed between the rivers Dee and Don. Its drift-slopes are generally cultivated up to about an average altitude of 900 feet, while the top is almost entirely covered with heather and turf peat. On the rising ground between Leochel Burn and Tullochvenus the rock is seen at several points, and is a dark-grey banded gneiss. In a quarry at Mains of Camphill the gneiss is associated with a hornblende chlorite rock composed of a confused aggregate of hornblende with grains of iron-ore and small scales of chlorite. A specimen from a quarry 300 yards north of Mains of Findrach, under the microscope, showed this rock to be composed of alternating dark and light bands. These light bands are chiefly composed of quartz and felspar, while the dark bands are rich in biotite. In the burn below Craigenhigh the granite is seen in close proximity to the gneiss. A specimen taken from a small quarry 300 yards to the north of the farm showed the rock to be a biotite muscovite gneiss, with foliation planes inclined to west and north-west. At the foot of the Black Hill above Rinnalloch a quarry for building purposes has been opened in a massive grey biotite gneiss. This rock furnishes a good

example of linear foliation. Microscopic sections, cut at right angles to the direction of stretching, show no parallel structure, while those parallel to the direction of stretching show this structure equally.

The top of Benaquhallie is a grey gneiss, with numerous veins of pegmatite and granitic intrusions. The rock is exposed at intervals along the ridge which connects this summit with the Green Hill. To the north of the Red Hill the gneiss occurs along with bands of brown quartzite. A microscopical examination of this quartzite showed that the rock is essentially composed of quartz, with garnets as an accessory mineral. It cannot positively be said that this rock is of clastic origin, as the original forms of the grains of quartz are no longer recognisable. On the northern slope of the Green Hill there is a considerable exposure of rock. It is generally a grey banded gneiss, with regular foliation planes all inclined to the south-west. Granite intrusions appear here and there along with numerous pegmatite veins, with large eyes of quartz. Microscopical examination of a specimen from this locality showed the rock to be a biotite gneiss, with granitic segregations. On the eastern slope of this hill, above Redwell, there is a small escarpment of hornblende schist, but on account of the thick plantation by which it is surrounded its relation to the gneiss cannot be determined. At Blackhill of Cluny a small area of coarse grey gneiss is surrounded by the grey granite of that district.

10. *Monymusk.*—The Green Hill of Cairnwilliam is composed of a peculiar rock, grey in colour, massive, and coarse. It is a cordierite-gneiss, resting apparently on the top of the surrounding granite, which is probably in place at no great distance from the surface. It is intersected by numerous pegmatite veins which increase in number as the granite is approached, and the rock has the look of having undergone intense metamorphism. On weathered faces these veins project, and interlacing one with another give the rock a honeycombed appearance. Weathering along the planes of foliation has also produced sharp ridges between long narrow grooves sometimes two inches in depth. Around King's Moss and in close proximity to the granite, these foliation planes disappear, and the rock becomes coarse and massive, with numerous veins of pegmatite. Under the microscope, specimens from this locality, examined by Mr Teall, were found by him to be composed of sillimanite, cordierite, magnetite, and zircon in minute grains and crystals. The sillimanite occurs in long, slender prisms, which are often aggregated into tufts and even dense masses in which the individual fibres are not distinctly recognisable. The cordierite occurs in colourless, granular aggregates, resembling quartz so far as its appearance in ordinary and parallel polarised light is concerned. In convergent polarised light the cordierite is seen to be biaxial and contains sillimanite and zircon as inclusions. The zircon crystals are surrounded by yellow pleochroic halos exactly as in the cordierite gneiss of Bodenmais. In one specimen examined with the microscope, this rock contained cordierite, sillimanite, magnetite, quartz, and a small quantity of andalusite, while another specimen from the same locality contained felspar as an additional constituent. This belt of gneiss has been traced eastwards from the Green Hill by Monymusk to Gallows Hill and between these two points it separates the Bennachie and Hill of Fare granites. It is very easily distinguished from the ordinary gneiss of this portion of Aberdeenshire by its hardness and peculiar weathering, and many boulders carried from this area have been found scattered over the surface of the adjoining Sheet to the east (77). Its microscopical characters show this rock to be a cordierite or fibrolite gneiss.

11. *Kincardine O'Neil.*—A narrow strip of gneiss occupies the extreme margin of the Map for about 2 miles between Torphins and Glassel. The rock is exposed on the Hill of Beltie, and in the railway cutting immediately W. of Glassel Station. It is a somewhat coarse biotite-gneiss, very rich in mica, and well foliated, with segregation veins and cores of white quartz. The foliation planes are usually much contorted, and are vertical or inclined at high angles.

12. *Dess.*—The gneiss appears again in the Slog of Dess, and at the fall is seen in contact with the granite. It is here associated with bands of hard very siliceous rock full of specks of pyrite, and also with a basic rock of doubtful origin, composed of biotite, chlorite, hornblende, felspar, and abundant sphene. The gneiss on the hill above also contains chlorite, iron ores, and sphene in small quantities. The junction-line with the granite is here difficult to determine, the one rock passing insensibly into the other by the introduction of innumerable veins or intrusions of granitic material along the planes of foliation of the gneiss.

13. *Aboyne and Tarland.*—This phenomenon is even more strikingly developed on Queen's Hill, immediately N. of Aboyne Castle. Here the gneiss is fine-grained and well foliated, the foliation planes being inclined to W.N.W. at angles of 20° to 35°. It is composed of quartz, felspar, and abundant black mica, with chlorite, garnet, and hornblende as accessory minerals. With the gneiss are intercalated bands of a very hard, fine-grained quartzose rock, perhaps originally a quartzite, but not now recognisable as such under the microscope. Both rocks have a hardened or baked appearance. Ascending the hill from the south, segregation veins and intrusions of granitic material begin to appear along the foliation planes of the more micaceous portions of the gneiss, and gradually increase in frequency until the rock presents the appearance of a coarse, foliated granite, the layers of black mica between the successive granitic intrusions alone remaining to represent the gneiss which the latter have so completely invaded. This rock, formed by the introduction and assimilation of the granite with the gneiss, occupies the col between Queen's Hill and Mortlich, but towards the foot of the latter hill the last traces of the foliated rock gradually disappear until the original unfoliated granite mass of which these intrusions are the apophyses, is reached on the hill slope above.

Westwards from Queen's Hill a well foliated biotite gneiss occupies the ground about Balnagowan, Gellon, and Mill of Coull. The foliation planes have a general inclination to the N.W., and are often overfolded and contorted.

The craggy hills that lie to the N.W. of Braeroddach Loch between Wester Coull and Dinnet Station, present some interesting varieties of rock, which it has been found difficult to classify or separate with any satisfactory degree of certainty. On the one-inch Map they have therefore been included in the gneiss, with which they seem to be intercalated. On Mullach Hill, at the southern end of this range, the rock appears to the naked eye as a coarse felspathic grit, with large rounded grains of felspar and quartz standing out in relief on the weathered surfaces. Under the microscope the rounded eyes of felspar are seen to be enclosed in a granulitic matrix, with small scales of brown mica arranged in planes which wrap round these felspar kernels. The evidence, therefore, though not altogether conclusive, is somewhat in favour of the rock being classed as a modified grit. On Scar Hill, the next summit to the N., with the same rock is associated a band of granitic-looking rock composed of felspar, both striated and unstriated, quartz, garnet, and biotite; perhaps a garnet-bearing granite. Half a mile further to the E. a rock whose microscopical character is that of the pyroxenic granulites occurs among

the gneissose schists and quartzites. It contains brown and pale hornblende, the latter with green borders and containing irregular nuclei of hypersthene, plagioclase felspar and iron-ores.

14. *Towie.*—The summits and northern slopes of the range, which, from Baderonach Hill to the Sockaugh, forms the watershed between Don and Dee, afford very little evidence as to the nature of the rock beneath. The ridges and glen sides are smooth and heather-clad, while the upper courses of the hill burns are cut through thick stony drift. On Craig Lea and Broom Hill, however, scattered blocks and angular debris of garnetiferous gneiss appear, and on the Sockaugh there are traces of a band of quartzite.

As the ground falls towards the Don, the rock begins to appear in the streams, and is seen pretty frequently along the Burn of Towie below Mill of Culfork, and in the Chapel Burn about Brunthill. It is usually a well foliated biotite-gneiss, often much folded and contorted, and contains many veins of pegmatite; one of which, on the White Hill, is of considerable breadth, and noticeable for the graphic arrangement of the quartz. Bands of white and yellowish quartzite are intercalated with the gneiss at Sinnaboth, Waterside, and on Truncie Hill; and at Middle Sinnahard and near Mill of Culfork, small quarries have been opened in calcareous schist and impure sandy limestone.

15. *General Remarks.*—As to the origin of the different types of gneiss described above, much yet remains to be determined, and it has been found impossible to draw any satisfactory boundary line on the Map between what may be considered as undoubtedly a metamorphosed clastic rock, and those gneisses which are probably due to the deformation of igneous masses. In the western and south-western portions of the area under consideration the occurrence of intercalated bands of quartzite and altered grit, and the presence of such minerals as andalusite and cordierite, point to the probable clastic origin of the gneiss of Towie, Leochel, Aboyne, and Corrennie Forest; while the granitoid character of the gneiss at certain points has been shown to be due to the intrusion of granitic material along the planes of foliation. In the east and south-east, however, and especially in the neighbourhood of Inverurie and Kintore, the granite masses are in many places surrounded by a belt of foliated granite-gneiss, in which a gradual passage can be traced from the unfoliated rock into a more or less fine-grained gneiss. The hornblende-gneiss of Dilly Hill, N. of Inverurie, is also undoubtedly due to the deformation of the outer part of a mass of fine-grained diorite, the unaltered core of which can be seen on Knocking Lew Hill above. In the Skene and Echt district, much of the granite is distinctly foliated, but the rock still remains so markedly granitic in structure, that it has been mapped and coloured as part of the granite area.

(2) Mica, Knotted, Andalusite, and Chiastolite Schists, with Associated Clay Slates, Quartzites, and Pebbly Grits.

16. This series occupies a large tract of country on the north side of the Don, extending from the Old Red Sandstone on the west to the granite of Bennachie, and forming the range of the Correen Hills. To the south of the Don they form the Callievar Hills, and stretch eastwards to the Leochel Water, where a narrow belt of granite separates this area from a smaller patch bounding the Howe of Alford on the south. West of the Old Red Sandstone area they occupy the margin of the Map, including the Clova Hills and eastern spurs of the Buck of Cabrach, and are terminated in the north by the serpentine of Tombhreac Hill.

17. *Correen Hills.*—The schist series presents few good sections on the northern side of this range, the slopes being heather-clad, and the summits usually strewn with weathered debris. A tolerably good section is, however, exposed in an old trackway crossing the Brackla Hill, near the farm of Backbrae. Here the nearly vertical beds form a sharp syncline, and the rapid alternations of mica and knotted schist, with their bands of quartzite, as well as the passage of one into the other are well shewn. It will be seen from the Map that a band of mica-schist lies along the northern slope of the Correen range from Tillymuick to the Hill of Midmedden, the beds dipping S. at high angles. The reappearance of this band on the south side of the syncline is indicated by several exposures of mica-schist on the slopes of the Black Hill, in the Corrie burn, and elsewhere; but the evidence is too scanty, and the ground too much obscured by drift, to admit of its limits being traced on the Map. A little west of the Brackla Hill section, at the farm of Upper Edingarioch, there is exposed a very beautiful pinkish-grey felspathic hydromica-schist. Under the microscope it is shown to consist of folia of a pearly-white micaceous mineral of the muscovite group, associated with biotite, granules of quartz, and a few isolated grains of felspar. It also contains a large quantity of magnetite in disseminated grains, together with patches of a chloritic mineral enclosing acicular crystallites. On the hill immediately above, there is a band of very coarse, pebbly grit, composed of rounded fragments of quartz and felspar in about equal quantities. It may thus be regarded as a pebbly greywacke. Proceeding westwards, the schists are well exposed at Silverburn, and in the deep "dens" of Chapelton and Drumgowan. At the latter locality they are associated with a massive, very hard, siliceous rock—an altered greywacke.

18. In the Casaiche burn at Knockespock, the mica-schists are seen still dipping S. at high angles, but west of this point they appear to die out rapidly, and the angular debris on the Mire of Midgates is composed of knotted and quartz-schist fragments. On the hill slopes to the E. and N.E. of Lumsden, the slates, quartz-schists, and quartzites of the series are well developed. The Carlinden burn gives a strike section of the slates, which here form a band 300 to 400 yards wide, extending in a N.E. direction from the edge of the Old Red Sandstone basin. In the upper part of the burn they lie at comparatively low angles, forming a flat syncline, and are here black, fine-grained, cleaved slates. Near Whitely they pass into grey, slaty mica-schist, wherein minute spots—which under the microscope appear as elliptical patches, consisting of light and dark areas disposed in zones, and probably representing incipient crystals,—begin to make their appearance. Immediately to the N. and S. of these slates, several zones of quartzite and quartz-schist, separated by narrow bands of knotted schist, rise from beneath the outcrop of the Old Red Sandstone. Their general strike, as seen in the burn of Allantersie, is to the E.N.E. with a northerly dip. At one point a little below the farm of Allantersie, the quartzite is interbedded with these layers of knotted schist. The slope of Badingar Hill is strewn with blocks of gritty quartzite and the rock can be seen in place at the crags called the "Craw's Nest." Another band of coarse, gritty quartzite, dipping to the N.W., extends from the roadside near Kildrummy School, over Ardhuncart Hill, and crossing the Mossat burn just above Invermossat, is continued for some way up the slopes of the Saplings Wood. These various bands cannot be traced for any distance to the E., and though from the nature of the ground, the evidence is scanty, it is probable that they thin out soon after reaching the hill top, as represented on the Map.

19. In a quarry by the roadside between Mossat bridge and Invermossat, and a little to the N. of the quartzite of Ardhuncart Hill, chiastolite-schist occurs in bands through a fine-grained slaty mica-schist, from which it is sharply defined. It consists principally of biotite and andalusite, with large crystals of chiastolite, a little muscovite and sillimanite are present, while opaque grains of a black substance, probably graphitic, are disseminated through the rock. The crystals of chiastolite are remarkably fine and perfect, presenting bold cruciform sections, with well-defined, dark, rectangular centres, and divided by diagonal lines. Although this is the only locality where chiastolite-schist has been observed in place, it is likely that it occurs elsewhere in the schist area, being difficult to recognise in the field, except where the crystals stand out in relief on weathered surfaces.

20. The southern slope of Ardhuncart Hill is strewn with large angular blocks of a very massive crystalline andalusite-schist, which is no doubt in place below. Under the microscope it is found to be composed of biotite, muscovite or some similar white micaceous mineral—and quartz; with andalusite, containing cloudy aggregations of dusty matter forming incipient crystals. It thus affords a good example of the passage from a knotted schist to a rock in which these aggregations reach their more perfect form as crystals of andalusite.

21. On the western side of the Old Red Sandstone basin good sections of the knotted and andalusite-schists are exposed in the streams that flow off the Clova Hills. The Mossat burn, from the fault at Auchmullen to the point where it leaves the Map, affords a continuous descending section in purplish-grey knotted schists, passing in places into andalusite-schist, with occasional bands of mica-schist. The beds dip steadily to the north of east, at angles varying from 20° to 35°. In the Muchie burn at Mid Clova, knotted and andalusite-schists are seen dipping E.N.E. at angles of 20° to 30°. Their faulted junction with the sandstone is well exposed in this burn; the schists near the point of contact are much reddened and contorted, and have a soft unctuous appearance.

The Burn of Corchinnan also presents a good section of schist. Here the beds are inclined at higher angles, often nearly vertical, the strike being generally a little south of east. As in the Muchie burn, the schists and quartzite bands near the fault are crumpled and reddened.

22. The rock that forms the southern slopes of the Tap o' Noth, a mile to the north of Rhynie, has, from its character over the greater part of the hill, been mapped as a knotted-schist. At the few points where it is exposed within the limits of this Sheet on the Braes of Scurdarg, it is a very massive, crystalline, grey mica-andalusite schist, shading into a fine-grained gneiss. The foliation varies in amount along certain planes, but is generally hardly apparent in hand specimens. Under the microscope the rock is found to be composed chiefly of andalusite, with folia of biotite and dispersed grains of magnetite; while it is traversed throughout by numerous bundles of diverging fibres of sillimanite.

It is worthy of notice that the andalusite and chiastolite crystals are developed in equal or even greater abundance and perfection in that part of the schist area which lies furthest from the great masses of igneous rock on the N. and E. For example, the chiastolite-schist of the Mossat Glen, and the beautiful andalusite-schist of the Clova Hills are situated from 4 to 5 miles at least from the nearest igneous intrusion. It is therefore highly probable that in this district, these rocks are the result of regional rather than of contact metamorphism.

23. In the southern portion of the Howe of Alford the only good section in the knotted schists is that exposed by the Strow and Long burns. At

the head of this stream fine-grained knotted schists with pebbly grits dip N. and N.E., at an average angle of 30°. Lower down the stream more bands of pebbly quartzite and knotted schists are seen, with a general inclination to north. Along the western edge of the Alford granite, there are a good many exposures of knotted schists. Their dip is rather irregular, and this may be due to the close proximity of the granite. Between Kingsford and the alluvial area around Strath little rock is to be seen, and in consequence the divisional line which separates this zone from the gneiss is rather indefinite. A specimen from near North Strone under the microscope shows that the schist there is composed of dark mica containing dense pleochroic spots, a granulitic aggregate of quartz and felspar, and large irregular patches of andalusite. There are also numerous opaque grains, probably of magnetite. The andalusite shows the characteristic pleochroism in places and includes bronze mica. At Tough, hard, grey, pebbly quartzites and grits form the basement beds of the knotted schist series. In the Linn Howe and Culthibert burns these dip to the E. and N.E. and rest upon bands of gneiss. To the east of the Haugh lands of Alford the knotted schists cover a small, oval area at the Free Church of Keig. In a quarry close to the granite there are two bands of broken purple schist with a S.S.E. strike. These bands are considerably altered and serpentinized along the joints, and are separated by a mass of protogene granite.

24. A little to the west of Breda the Don runs over a rock bottom for about $\frac{1}{4}$ of a mile. At the east end of the section the beds are vertical. They are then inclined towards the west at an angle which from this point gradually diminishes to 30°. They consist of knotted schists with a few andalusite-schist bands. Near the elbow of the stream a fault interrupts the continuity of the section, and on the west side of this dislocation the dip is an easterly one. The section is now made up of bands of coarse pebbly grits. The pebbles vary in size up to 1 inch in diameter, two-thirds of these are composed of quartz, while the remainder have been derived from the denudation of a felspathic rock. The river bends sharply round the ruined Kirk of Forbes and has at the same time cut into the steep side of the Wood Hill, exposing a good rock section. The beds dip to the east and consist of alternating bands of massive knotted and silvery-grey andalusite-schists, and fine specimens of andalusite-schists are scattered as loose stones over the surface of the ground around Bithnie. These blocks have undergone considerable weathering, and the rhomboidal crystals, often projecting in full relief, are often only attached by one side or corner to the surrounding matrix. On both sides of the rock gorge of Invermossat the steep slopes are thickly covered with debris of pebbly quartzite, knotted, and andalusite-schist.

25. A glance at the Map shows that the largest area covered by the knotted-schists of the Alford valley lies to the north of the Don. Good sections are exposed by the various streams that rise in the Correen Hills and join together to form the Esset Burn. Between Balquharn and Tullynessle knotted schists with grit and quartzite bands dip in various directions to the south. Thence to Terpersie Castle the stream runs through an alluvial flat above which bands of knotted-schist considerably decomposed are inclined to the north-west, while at the ford below Hillock of Terpersie beds of andalusite-schist and quartzites are seen on end with a N.E. and S.W. strike. The various burns that run off the southern slope of the Correen Hills join at this ford, and all show a gradually ascending series, chiefly made up of andalusite and knotted schist, with a few pebbly and quartzite bands having a north and north-west dip. In the Blacklatch burn a belt of clay-slate appears

in the midst of the andalusite-schist series; the slate is black and some of the bands are spotted. It is overlaid by a few feet of grey mica-schist also spotted, which is succeeded by andalusite-schist. This zone of slate has been traced up to the top of the Limer Shank and in a north-easterly direction as far as the watershed. As the Correen Hills are closely covered with heather, little rock is seen on their surface. In the Correen quarry there is an excellent section of silvery andalusite-schist bands. Some of these are only spotted or else have very small crystals, while in others andalusite crystals of the usual size have been developed. The beds are inclined to the north-west at an average angle of 40°.

26. A specimen from Correen quarry examined under the microscope shows that the matrix is a silvery mica-schist. The dark spots are somewhat imperfectly developed crystals of andalusite or cordierite crowded with fine dusty magnetite. That the opaque substance is magnetite, and not carbonaceous matter, is proved by the fact that minute fragments of the crystals may be picked out from the powder of the rock under the microscope by means of a weak magnet. Andalusite is certainly present in the rock, but as many of the cross sections of the mineral producing the spotted appearance give indications of a six-sided outline, it is possible that cordierite may also be present. The matrix consists of white mica, quartz and magnetite. The magnetite occurs in larger grains and crystals than those present in the andalusite. There are also a few grains and crystals of zircon and tourmaline exactly similar to those occurring in so many sands.

In the Suie Burn there are occasional exposures of andalusite and knotted schists, all of which are inclined to N. or N.W. Between Tullynessle and the western edge of the Bennachie granite none of the burns afford any section, but in quarry openings and on the hill tops sufficient evidence has been obtained to show what is the nature of the rocks in place. The bands that occur over this area are similar to those that appear in the Esset Burn, and consists of knotted and andalusite-schist, with pebbly and quartzite bands. There is a considerable diversity of dip, but the general inclination is from N. to W.

Massive (Eruptive) Rocks associated with the Schists.

(1) Granite.

27. To the north-east of the Howe of Alford lies the granite of Bennachie and Cairnwilliam. The outline of the area forms a somewhat irregular circle 6 miles in diameter.

Bennachie.—The granite of Bennachie and Millstone Hill, which forms the northern extension of the great granite mass lying to the south-east, may be considered first as the most important development of this rock to the N. of the river Don. It is a typical pink or flesh-coloured granite, composed of orthoclase felspar, quartz, and black or dark brown biotite. The crystals are usually much of the same size; but in places, and especially on the weathered crags of Bennachie, the felspar becomes coarse and often porphyritic, the quartz forming large rounded blebs with occasional perfect crystals. The mica is always in small flakes, and far less conspicuous than the other component minerals. The picturesque crags which crown the heights of Bennachie have been produced by the tabular weathering of the coarser bands of rock along horizontal joints. The whole of the rock, from the abundance of felspar, decomposes readily, and the summit and flanks of the mountain are in many places covered to a depth of some feet with loose sandy debris. This

detritus, carried down by the mountain streams, lies thickly over the hillfoot, thus effectually concealing the junction of the granite with the diorite to the north. The boundary line drawn on the Map immediately to the south of Oyne, is, for this reason, a somewhat conjectural one. The only locality where the actual junction of the two rocks can be seen is in a small burn falling into the Gady at Kirriemuir, about a mile to the south of Kirkton of Premnay. The diorite is here much decomposed, but specimens may be obtained showing the later intrusion of the granite through the basic rock. From near this point the boundary line bends nearly at right angles, and runs in a S.S.W. direction along the slopes of the Black Hill, to the river Don at the Bridge of Keig. The junction of the granite with the schists and quartzite of the Correen Hills may be seen at several points along the burn of Corriemuir, to the north of the farm of Auchnagathle; as also in the Fore Burn, above Lickleyhead Castle.

On the eastern side of Bennachie, the actual limits of the granite are everywhere obscured by drift and hillwash. The approximate boundary line is drawn in a S.S.E. direction from Pittodrie along the foot of the hill slope to Dorlethen, and thence for about 2 miles down the western bank of the Braco Burn. It then bends to the south-west near Fetternear, and passing to the west of the Gallows Hill, and through the Red Moss, meets the alluvium of the Don at Delab.

A remarkable segregation vein of quartz, mixed with kaolinised felspar and some decomposing hematite, occurs in the granite near Pittodrie on the N.E. shoulder of Bennachie. It runs due N. and S. for more than a mile, varying in breadth from 50 to 200 yards.

28. *Clatt.*—An irregularly shaped mass of granite, about 2 miles in length, lies at the foot of the Correen Hills, to the south of Rhynie and Clatt. It divides the diorite from the schists of the Correen range, and at its western extremity abuts against the Old Red Sandstone. The granite dyke which pierces the serpentine at Knockespock is evidently in connection with this mass, proving the granite to be of later origin than the serpentine. The rock is fine-grained, and contains a large amount of decomposing hornblende. It thus appears to have no affinity with the coarse micaceous granite of Bennachie. An oval boss of a similar rock occurs at Gartnach Hill, a mile to the N.W. of Clatt.

Kennethmont.—To the N.W. of Kennethmont there lies an area of hornblendic granite, of which the extreme edge appears within the northern margin of the Map. As this will, however, be treated of in the Explanation of the Sheet to the north, a detailed description is here unnecessary.

Several other small intrusive masses and veins of granite and pegmatite occur at various localities through the diorite and gneiss areas of the N. and E., as about Durno, Daviot, and at Middleton to the S. of Chapel of Garioch. The most important of the pegmatite veins extends for about a mile between Portstown and Boynds to the east of the river Ury. Many of these pegmatites contain schorl, often in large and perfect crystals. On the Salters and Brackla Hills, south of Leslie and Auchleven, there are also numerous patches and veins of red granite, which are no doubt offshoots from the great mass of Bennachie.

29. *Alford and Cairnwilliam.*—The granite of Cairnwilliam and Pitfichie Hills consists of a tolerably uniform coarse pink rock. The red orthoclase felspar crystals give the characteristic colour. On many of the weathered portions along the top of Cairnwilliam these measure over 2 inches in length. Biotite is present in small quantities, while blebs and crystals of smoky quartz are scattered through the granitic base. As felspar is the chief constituent of this rock, and exists as large crystals scattered through a fine-grained base, the rock of Cairnwilliam may be regarded as a granitic

porphyry. Microscopical examination shows that the porphyritic constituents are orthoclase, plagioclase, dark mica, and quartz. The felspars are often idiomorphic and zonal. They include crystals of the dark mica, and in one case an irregular mass of micropegmatite was observed in them. The quartz occurs in the forms characteristic of the quartz porphyries. The ground mass is a microcrystalline aggregate of quartz and felspar, with a few grains of iron ore, and some small scales of dark mica. In the quarry behind the Free Church Manse of Keig the dark mica of this granite is largely represented by chlorite containing minute particles of iron ore. The quartz also occurs in aggregates of irregular grains, and is traversed in numerous directions by lines of inclusions, which give it a dirty appearance. At Bridge of Keig a contact junction between the granite and schists is exposed in the bed of the river. The southern boundary line of this mass is rather indefinite, owing to the thick covering of drift and hillwash which covers the country between Green Hill and the Don. The granite of the Vale of Alford forms an irregular mass, with a belt that projects to the south and east as far as Lynturk. About one half of the granite is covered by the alluvium of the "Howe," but over this flat there are numerous exposures which show the position of the rock beneath. Between the railway and the river the Bents Burn has cut down to the rock, and around Mains of Haughton several deep ditches and sinkings have laid bare the granite. This portion, although it forms the western extension of the Bennachie mass, has little resemblance to it as far as colour and texture are concerned. On the left bank of the Esset Burn below Midhill, the junction line between the granite and knotted schists is well exposed. At this locality the rock is in such a decomposed condition that sand martins have excavated holes in it for the purpose of building their nests. At Sylavethy quarry the granite consists of quartz, felspar, mica, and hornblende, and scattered through the rock are large knots which under the microscope appear to consist of small broken crystals of a hornblendic mineral. The boundary line from the Esset Burn passes up the centre of the Gallows Howe. Knotted schist bands crop out along the northern slope, while the southern bank is composed of decomposed granite.

Between Alford village and the church several quarry openings show the position of the rock. It extends westwards as far as Shannoch, where it is seen in close proximity to a bed of knotted schist. At Newton of Breda a contact junction is exposed, and from this point, till opposite Droichsbridge, the edge of the granite is well defined and occupies the right side of the Leochel Burn. The rock now changes from grey to pink, which is the prevailing colour of the belt that extends from Kingsford to Lynturk. Between these two points the boundary line is rather uncertain, and has been traced to a large extent by the position of granitic debris at the surface. Fresh pink granite has been quarried at Knowhead, and in a small opening to the south of the village of Alford the rock, very much decomposed, is seen against a grey schist band. Opposite the infant school another contact junction is exposed, accompanied by a small dyke of basalt. From the Manse of Tough to about 300 yards N.W. of Seats a fine contact junction is shown along the bed of the Culthibert Burn. At this locality, beds of pebbly quartzite abut against a red granite which has baked and hardened these quartzites for some distance from the line of junction. Between Seats and the foot of the Green Hill a narrow belt connects the Vale of Alford granite with the large area that fills the south-east corner of this Sheet. Small outlying bosses of this rock occur at Craich, Dorsell, Roadside, and on the northern slope of Sockaugh.

30. *Tillyfourie.*—To the north of Craigmaud Moss the railway passes through a mass of rocks which is made up of bands of gneiss and quartz schist, with an apparent vertical dip. These bands are about 50 yards in breadth, and appear to be surrounded by grey granite. The position the gneiss occupies, with regard to the granite, is well exposed in the rock cutting to the west of Tillyfourie Station. In this section numerous bands of gneiss alternate with the granite, and these dip N. 30 W. at an average angle of 60°. The granite is grey and foliated, the gneiss micaceous and schistose. The bands of gneiss often abut against the granite, the line of separation being only a fine joint, while the rock is perfectly continuous. In some cases the granite is seen running out into the gneiss, and at other portions of the section the reverse takes place. A microscopical examination of the gneiss by Mr Teall showed the rock to be composed of large crystals, crystalline grains, and crystal fragments of quartz and felspar, together with a considerable amount of microcrystalline granulitic material and dark mica. The dark mica occurs for the most part along wavy planes which define the foliation, and sweep round the larger constituents. Hair-like needles (rutile?) occur in the quartz. There is often a rude kind of parallelism in the planes of inclusions in the quartz which is irrespective of the orientation of the individual crystals. On the hillside to the south of Tillyfourie Station a quarry has been recently opened. Here the rock is pink in colour, and identical in composition with the granite of Cairnwilliam and Bennachie.

31. *Kemnay.*—Between Kemnay and Kintore the granite is of a somewhat different character from that lying to the north of the Don. It is a fine-grained, compact, light grey, or nearly white rock, composed of white plagioclase, microline, quartz, and two micas. Large quarries have been opened in this rock at Kemnay and Tomsforest, besides many other smaller workings; and at the former locality the granite has been largely wrought for more than twenty-five years. It is employed for paving, dock-work, ornamental and general building purposes; and from this quarry was obtained all the stonework used in the construction of the Forth Bridge.

In the Kemnay quarry the white rock is accompanied by bands of a coarser pinkish variety, while both are traversed by thin vertical and oblique dykes of grey mica-trap. At Shaw Hill, immediately S. of Port Elphinstone, there is a small mass of somewhat coarse reddish granite, which, at its edges, shows a rapid passage from an entirely unfoliated rock into the coarse granite-gneiss by which it is surrounded. This is well seen in a small quarry at the farm of Crichie.

32. *Skene and Echt.*—The south-east corner of this Sheet is occupied by an area of granite that covers more than 100 square miles. From Tillyfourie and Kintore the northern boundary of this mass is badly defined. The portion around Fetternear House is indicated by granite debris on the surface. At Tomscairn and Scare Wood the rock is grey, and to the west of Cluny Church lies a small area of gneiss surrounded by granite. To the south of Castle Fraser the granite becomes pink and continues so as far as Firley and Skene Mosses. To the east of these two localities it rapidly changes its character and becomes a highly foliated rock. North and south of Loch Skene, and all along the edge of the Sheet, the granite is not only foliated, but has also associated bands and masses of gneiss. These bands are granitic, and were doubtless produced by the same earth movements which formed those to the west. A small part of this area lies on the east side of the Don opposite Kintore, and extends to Upper Kinkell; it is chiefly a coarse grey decomposed granite. Under the microscope a specimen from Finarey to the east of Echt showed this rock to be a granite with more basic inclusions, and con-

sisting largely of felspar (striated), a little quartz, green hornblende, biotite, and sphene. Surrounded by this matrix a dark patch appeared in the slide, composed of the same constituents but much richer in biotite.

33. *Hill of Fare.*—Between Echt and the southern limit of the Map the Hill of Fare forms a prominent point in the landscape of this portion of Aberdeenshire. Viewed from the north-west the top of this hill appears as one of those flat tablelands so characteristic of the denudation of a large granite area. In the district round about Tillybirloch numerous exposures of the granite may be observed in various streams, ditches, and small quarry openings. Everywhere it is a coarse pink granite of the usual Bennachie type, and always more or less decomposed. The rock exposed along the south side of the Hill of Fare is much fresher; at Green and Cluny two large quarries have been opened. On account of the large peat mosses and general cover of drift between Garlogie and Drum, little rock is to be seen at the surface. To the south of Drum Castle there is a small exposure of a grey hornblendic granite.

34. *Tornaveen.*—From Moss-side to Tornaveen the boundary of the granite is not sharply defined. The Glenshalg and Learney Hills are formed of the typical pink granite of Bennachie. To the south-west of Tornaveen a micaceous crumpled and contorted gneiss impregnated with bands and veins of granitic material occupies a small space. From this point the boundary line has been traced northward by Nether Broomhill and Tolmaads. The hilltop to the south of the former locality is entirely composed of pink granite considerably decomposed. The Beltie Burn for a short distance to the north of Tolmaads runs through a small den excavated in a coarse pink granite with large felspar crystals. About 100 yards north of the point where this granite is last observed, bands of grey micaceous gneiss are seen, containing abundant small veins of pink granitic material. From Tolmaads to Rinnalloch the limit of the granite is badly defined, and the few exposures seen in shallow openings show that the rock is now so thoroughly decomposed that it can be dug out with the spade to be used as sand and gravel for building purposes. In the wood to the north of Rinnalloch a small quarry has been opened in a massive grey rock, two-thirds of which are composed of a fine-grained grey granite, while the remaining portion consists of thin laminæ of grey gneiss, as if the granite had invaded and absorbed the original gneiss. From this point northwards the granite appears along the foot of the Green Hill of Tillyfourie in a good many openings.

35. *Cromar.*—From Lumphanan and Kincardine O'Neil the granite extends westwards through Tarland and Coldstone to the edge of the Map, forming a band from 2 to 4 miles in breadth. The northern limit follows pretty much the line of the road between Tulloch Venus and Tarland, but the actual position of the boundary line is generally obscured by drift. The junction of the granite with a fine-grained quartzose-gneiss or mica-schist is, however, seen in a small roadside quarry a little to the E. of Corse Castle, and again 3 miles farther to the W. at the slack of Tillylodge, where it is in contact with gneiss of a somewhat coarse granitoid character. The southern boundary line crosses the railway immediately to the E. of Aboyne, and follows the line of the glen between Queen's Hill and the Hill of Mortlich. The interesting relation of the granite to the gneiss at this locality has been already described. From this point the boundary is continued by the Mill of Gellon and Wester Coull to the Black Moss, whence it enters the Sheet to the south. The granite throughout the greater part of this area resembles in character that of Bennachie.

It is composed of glassy quartz, a little biotite, and flesh-coloured felspar in large and often porphyritic crystals. The latter is mostly orthoclase, but microcline, sometimes of a deep red colour as on Blelack Hill, is often present. Between Lumphanan and Torphins a fine-grained muscovite-granite is exposed in the railway cuttings on Sundayswells Hill, and near Craigmyle. At Craigmyle the muscovite appears to be secondary, and there are traces of granophyric structure. Veins of this rock are seen traversing the coarser biotite-granite in the railway cutting at Wester Beltie, and it is probable that the muscovite-granite is the latest of the granitic intrusions in this district.

(2) Felstone, Quartz-Felsite, and Felspar-Porphyry.

36. These rocks are nowhere largely developed in this district. A mass of felsitic rock about half a mile in length, and with very irregular outline, is intrusive through the serpentine of Tombhreac Hill. It varies much in character, presenting at the edge usually a compact deep red felsite, but becoming porphyritic towards the centre, and passing in places into a fine-grained granite that shows traces of foliation. The rock is throughout much decomposed, and is often quarried for sand. Its junction with the serpentine is irregular, the felsite advancing in long tongues into the former rock, which is much baked and reddened at the point of contact. In the Broom Stripe, a little to the west, and probably in connection with the mass described above, there are several dykes and masses of felsite and porphyry. The latter is a beautiful rock composed of large crystals of pink orthoclase felspar thickly set in a dark felsitic base. Other small intrusive masses of pinkish felsite and white felstone occur at Windyfield and on the slope of the Old Hill, near Rhynie. There are also several small dykes of felstone and quartz-felsite scattered through the schists and gneiss of the Clova Hills, which, however, call for no special remark.

37. A compact cream coloured felsite dyke, with a N.E. and S.W. course, intersects the knotted schists for several miles between the Don and the Suie Burn. Several others of smaller size cut across the schists in the Whitestone and Colburns. A broad and well-marked dyke of quartz-porphyry extends from Tibberchindy to Droichsburn, while a smaller one of red felspar and quartz-porphyry intersects the knotted schists and gneiss to the south of Alford village. A few pink and red felspar-porphyry dykes with a north-east course appear in the Parish of Tough, and on the flanks of the Green Hill are several large ones. These have a fine-grained drab felsitic base through which are scattered crystals of quartz and orthoclase-felspar, the latter sometimes measuring $1\frac{1}{2}$ inch in length.

38. In the S.W. part of the Map several dykes of felsite and quartz-porphyry will be seen traversing both the granite and gneiss, and in some cases cutting across the line of junction between the two. The most noticeable of these runs in a N.N.W. direction for over 2 miles, extending from Kincardine Lodge to the Stot Hill, with a singular uniformity of breadth of about 40 yards, and wall-like sides. It is composed of small porphyritic crystals of orthoclase and rounded blebs of quartz, set in a brick-red felsitic base, with specks of a green decomposing mineral, probably mica. Between Mineu and Stranduff this dyke traverses fine-grained muscovite-granite, and S. of the latter point a coarser variety with biotite and hornblende. Other smaller dykes occur at Tolmaads, Campfield and N. of Tarland, at the last named locality traversing the gabbro-diorite.

(3) Syenite.

39. A band of syenite extends from the foot of the Correen Hills at Knockespock for about 3 miles in a north-easterly direction, forming the hills of Johnstone, New Leslie, and the Gallows Hill. The junction with the diorite is well exposed in a quarry at the roadside near Mill of Johnstone, where veins of coarse syenite, composed of pink felspar and hornblende, may be seen extending from the parent mass and traversing the diorite, here a greenish rock containing large crystals of well striated felspar. In another roadside quarry at Hillhead of Leslie, the rock is chiefly made up of hornblende and pink orthoclase felspar. Striated felspars are present in smaller quantity, with a little mica, but no quartz can be detected. The rock here appears to be a passage between diorite and hornblendic granite, but the absence of quartz justifies its claim to description as a syenite. A tongue of similar rock, the southern extension of a mass to the north, comes within the margin of the Map, south of the railway, about half a mile below Wardhouse Station. Two small bosses of syenite also occur at Seggieden and Mosshead, south of Kennethmont. The latter is brought into contact with the Old Red Sandstone porphyrite, by the small fault which throws the members of the sandstone series down to the north-west.

The coarsely crystalline rock which forms the top of Dunnideer Hill, and is seen in place beneath the ruins of the old castle, has been provisionally mapped as syenite, but from its generally decomposed condition, its exact character is difficult to determine. The rock contains two felspars, white and pink, the latter much kaolinised; dark brown hornblende, no quartz; mica, zircon, perhaps a little unaltered biotite; and numerous stout prismatic crystals of apatite(?) It would thus seem to be a syenite. A small patch of a similar rock occurs on the top of Flinders Hill, a mile to the west of Dunnideer.

(4) Diorite.

40. The mass of basic igneous rock which occupies the northern margin of this Sheet, and has been mapped under the general heading of diorite, includes several varieties of that rock, such as mica- and augite-diorite and labradorite rock, together with small areas of olivine- and hornblende-gabbro. As, however, the true character of many of these rocks has only become apparent under the microscope, it being usually impossible to separate them from each other in the field, no attempt has been made to assign to them any definite area on the Map, further than that indicated by the printed legend.

The southern boundary of the diorite runs in a nearly due E. and W. line from Barra Hill south of Old Meldrum, to the western margin of the Map, being successively in contact with the Inverurie gneiss, the granite of Bennachie, the schists of the Correen Hills, and, on reappearing from beneath the Old Red Sandstone basin at Rhynie, with the serpentine and gneiss of Tombhreac and Clayhooter Hill.

41. *Daviot, Oyne, Insch and Leslie.*—Between Old Meldrum and Insch the diorite varies a good deal in character, the most general type being a rather fine-grained, bluish or greenish-grey rock, composed of hornblende and white-plagioclase felspar in about equal proportions, with occasionally a little biotite and quartz. With this is associated a coarsely crystalline and often very felspathic rock—in which decomposing crystals of green hornblende are sparsely disseminated through a base of white felspar. A rock of this class, from New Seat near Leslie, appears under the

microscope as a confused mass of large plagioclase crystals in a fragmentary condition, suggesting crushing; together with a few patches of chlorite and magnetite, and may be called labradorite rock. The harder, more hornblendic varieties form the characteristic rough knobby eminences which rise everywhere through the boulder-clay to the north of the Ury and Gady burns, the hollows between the knolls being usually filled with drift. When the rock is coarse and contains much iron, it crumbles down rapidly into sand, the harder cores weathering out in large exfoliating spherical blocks, which often present the appearance of huge rusty cannon-balls embedded in loose brownish sand; while the more felspathic rock more often weathers in small rectangular fragments. West of the syenite area of New Leslie and the Gallows Hill, the mica becomes a more important constituent, occurring in large porphyritic aggregations of biotite scattered through a finer-grained base of hornblende and greenish-white felspar, with a little quartz, apatite, and epidote.

42. *Clatt.*—In the neighbourhood of Clatt, orthoclase felspar is also sometimes present, and veins of true syenite are seen traversing the diorite in several quarries near Newbigging and Auchline. In a roadside quarry at Bridge of Johnstone, Leslie, the junction of the syenite with the diorite is well exposed, branching veins extending from the syenite mass into the latter rock, which is here an augite-diorite. Under the microscope this rock presents some interesting features. It appears to be composed essentially of pyroxene, hornblende, and plagioclase; the dark-green hornblende is pierced by numerous prisms of apatite, and in some cases hornblende forms the border of crystals of augite. The central portions of some of the pyroxenic minerals are finely striated like diallage, and numerous inclusions within the pyroxenes are distinctly orientated. Plagioclase is abundant, and patches of magnetite, with a small quantity of what appears to be biotite may be detected.

43. *Lesmoir.*—On the western side of the Old Red Sandstone basin the rock becomes a typical mica-diorite. It is this variety which forms the rugged crags that crown the hills about Creak and Balhinny, and form, with their picturesque tabular weathering, so striking a feature of this part of the country. The rock is usually coarsely crystalline, with the crystals much of the same size, but the biotite sometimes occurs in porphyritic aggregations through a fine-grained base of felspar and hornblende. Under the microscope the chief component minerals are found to be plagioclase, quartz, and biotite, with occasionally a little orthoclase and hornblende; while apatite, chlorite, and epidote are also present in varying quantities; the rock is thus a quartz-mica-diorite. In the Den of Craig, at the falls immediately below Craig Castle, a beautiful rock contains large porphyritic crystals of white felspar scattered through a dark fine-grained matrix. The microscope shows the former to be crystals of plagioclase exhibiting zonal structure, and the latter to be a congeries of minute lath-shaped felspars with grains of pyroxene, so that the rock may be termed a diabase.

44. *Towie.*—On the northern bank of the Don, a little below the Church of Towie, an outlying mass extends for about $1\frac{1}{2}$ mile between the farms of Fichlie and Drumallachie. This is a compactly crystalline rock, rich in hornblende, with a few scattered crystals of biotite. It is intrusive through gneiss, but between Fichlie and Ley is in contact with a small boss of granite, which is in places foliated and transversed by veins of pegmatite.

(5) Gabbro.

45. In contiguity with and passing into the serpentine of Barra Hill, occurs a compact black rock with large crystals of white felspar,

which, from its character under the microscope, may be classed as an olivine-gabbro. It contains large crystals of olivine, partly converted into serpentine; pyroxene in broad brown or pink crystals, perhaps in part diallage; plagioclase in large kaolinised crystals with a green serpentinous or chloritic mineral along the cleavage cracks, and a little magnetite. This rock may be examined in a quarry opposite Barra Castle, and in a few exposures on the southern slopes of Barra Hill.

The railway cutting immediately east of Pitcaple Station has been made through a rock, which, while hardly distinguishable in the field from a fine-grained diorite, is shown by the microscope to be also an olivine-gabbro. Its constituent minerals are plagioclase in fine bold crystals with broad twin lamellæ; a little microcline; augite partly altered into diallage, some of the augite showing pale red and green pleo-chroism; olivine, biotite, magnetite, and ferrite.

An altered and serpentinised rock which may be provisionally classed as an altered gabbro occurs in the neighbourhood of Insch, and is well seen in quarries at Rothney Hill and Picardy Heugh under Dunnideer. A section from this last locality appears under the microscope to consist chiefly of plagioclase with a green secondary mineral, chloritic or serpentinous, distributed along the fissures and in irregular patches. Large areas of the slide are occupied by a deep red and green opaque substance, which is apparently serpentine; olivine seems to be present, and ilmenite surrounded by leucoxene, a little biotite, with apatite in numerous crystals, complete the list of component minerals.

It is probable that gabbro occurs at many other localities between Old Meldrum and Rhynie besides those that have been described above, and an extensive series of microscopic sections would no doubt reveal the presence of diallage in many places where it cannot be detected by ordinary observation in the field.

46. *Tarland.*—The greater part of the rising ground lying between the village of Tarland and the southern slopes of the Broom and Sockaugh Hills is occupied by a basic rock which shows signs of having undergone considerable alteration, and may be generally described as an amphibolite or gabbro-diorite. The component minerals are usually plagioclase-felspar, brown or green fibrous hornblende, mica (scarce), and iron-ores. The hornblende is probably secondary. Most of the ground is obscured by thick drift, but the rock can be seen at Outfield of Tarland, Westfield, Cothill, Wester Migvie and in the burn of Old Mill. At the last named locality the rock is markedly schistose, and under the microscope the cataclastic character of the felspars, and general fluxion structure is well shown. The junction of the amphibolite with the surrounding granite and gneiss is nowhere exposed, but, like the great diorite area to the west with which this mass is no doubt connected, it is almost certainly of earlier origin than the granite with which it is in contact on the south.

47. *Alford and Leochel.*—At North Strone, Cairn Hill of Tillyfour and Mains of Camphill there are three small areas of well foliated dark-green hornblende-schist, which may probably be the result of the deformation of a basic igneous rock.

48. *Torphins.*—Between Torphins and Lumphanan a considerable area is occupied by a basic igneous rock, which varies considerably in character at the different localities where it can be seen. The most westerly exposure is near the farm of Braehead, where the rock is found to be composed of hornblende, plagioclase-felspar, biotite, quartz, and abundant apatite, with iron-ores, sphene, and epidote as accessory minerals, and may be described as a quartz-mica-diorite or tonalite. Eastwards from this point the rock is seen at Gordonstone, Stranduff, and Hindrum, and at

the last locality has perhaps more the character of hornblende-granite. Specimens from the roadside at Footie, a little farther to the east, show plagioclase-felspar, green fibrous hornblende, and iron-ores as constituent minerals, and the rock is here probably a modified gabbro, now a gabbro-diorite. In the railway cutting half a mile W. of Torphins Station, and on Sundayswells Hill, it again appears in the form of quartz-mica-diorite, and is in contact with a fine-grained pink muscovite-granite. A mile to the W., in a small quarry near Powdagie, this fine-grained granite is seen traversing the basic rock, which is here micro-crystalline, but under the microscope is found to consist of felspar (mostly striated), brown mica, and pale green pyroxene, with iron-ores and sphene. A band of rock is seen in the burn immediately to the N. of Lumphanan station, which may also be described as a diorite or massive hornblende-schist, being composed of hornblende and felspar, with traces of iron-ores.

(6) Serpentine.

49. A glance at the Map will show that the serpentine is entirely confined to the diorite area of the north, where it occurs in a series of irregular patches extending in nearly a straight line across the Map. The most eastern of these stretches from the rising ground immediately above the Mill of Bourtie to Barra Hill, where the serpentine forms the crags which surround the camp on the hilltop. There is also a small exposure in Fordalehouse Wood, at the extreme margin of the Map. It is a hard compact black rock, and is largely quarried about Bourtie for road metal. Microscopical examination shows the rock to be composed of yellowish-brown serpentine, traversed by numerous veins of magnetite and limonite, forming an irregular network. The serpentine appears to have been formed from olivine, inasmuch as the form of the original crystals is retained, though no unaltered olivine can be detected. The rock is thus due no doubt to a metamorphism of the olivine-gabbro which is contiguous to it.

50. Serpentine is next found on the northern bank of the Gady Burn, west of Kirkton of Premnay, and though generally covered by drift, may be seen in a field-road near the farm of Newton. At Leslie, 2 miles farther west, it forms a patch of irregular outline, a mile and a half in length. In a quarry on Hawkhill the rock is a beautiful variety, being dark-green in colour, veined and streaked with chrysolite, and with the joint-faces often coated with noble serpentine and asbestos. The next area, between Chapelton and Black Hillock, is in contact with the schists of the Correen Hills, which, at the junction, are considerably serpentinised. At Knockespock, close at hand, a similar patch of serpentine is traversed by a dyke of rather coarse red granite, and is in contact on the south with mica-schist. Crossing the Old Red Sandstone basin, the Hill of Tombhreac, or Towanreef, as it is usually pronounced, is found to be composed of dark-green serpentine, veined with steatite, and containing crystals of enstatite. It is traversed by several dykes and masses of felsite and orthoclase porphyry, which are described under their respective headings. The neighbouring hills of Cnoc Cailleach, Creag Dearg, and the Red Crag are formed of a harder and more crystalline variety of the same rock, with a rusty ochreous weathering; and small patches also occur at Scurdarg under the Tap o' Noth.

51. In most of the localities last mentioned a passage can often be traced from the serpentine into the surrounding basic igneous rock; and in the heart of the Towanreef mass there is a small patch of entirely unaltered

rock. These facts, together with the irregular outline of the various areas, and the microscopical character of the rocks at Barra Hill, show that the serpentine has probably been formed from the basic igneous rock by a process of selective metamorphism ; such portions as contained more or less olivine yielding most readily to the causes which produce serpentinous metamorphism.

52. *Order of Succession.*—In considering the probable order of succession of the igneous rocks described above, the diorites and gabbros may be regarded as the oldest of the more important and still recognisable masses of igneous rock in the district, though it is very possible that certain locally developed rocks among the schists may represent intrusions of a still earlier period. Whether the basic rocks were all intruded at one time there is little evidence to show, but it is not unlikely that the amphibolites and foliated gabbros of Tarland are of earlier origin than the massive mica-diorite of Lesmoir and Rhynie.

Next in order come the granites and syenites, and while the evidence for determining the relative ages of these acid intrusions is scanty, it is probable that the granite masses of Bennachie, Cairnwillism, and the Hill of Fare are of much the same date. In Cromar, the fine-grained muscovite-granite is certainly later than the coarser biotite and hornblende-bearing varieties. To a later period must be assigned many of the felsite and porphyry dykes which traverse both the granite and the surrounding schists. They, however, may be segregations from, or the latest phase of the acid intrusions, or are possibly due to both causes. To these succeed the contemporaneous lava flows of the Old Red Sandstone Period, represented by the diabase-porphyry and amygdaloidal lava of Contlach and Rhynie. Latest of all are the basalt and dolerite dykes that traverse the Old Red Sandstone, and which have been assigned to the Tertiary Period.

Lower Old Red Sandstone.

53. The Old Red Sandstone basin occupies a narrow belt of country 9½ miles in length and from 1½ to 2 miles in breadth, near the N.W. margin of the Map. It extends from Glaschul Hill, a little to the south of Kildrummy Castle, due north across the watershed at Lumsden, and thence, bending a little to the east, coincides with the valley of the Bogie northwards from Auchindoir and Rhynie, and leaving the Map near the farms of Smithston and Blairindenny, is continued in the adjoining Sheet (86) for about 3 miles in the same direction. It is bounded on the west side by a well-marked fault, by which the highest beds are successively let down against the various massive and schistose crystalline rocks of the metamorphic area. From Glaschul Hill, at the southern end of the basin, and as far as Longley, the sandstones are brought into contact with the gneiss. North of Longley, along the slopes of the Clova Hill they abut against the different varieties of schist; the contact being well seen in the Mossat Burn at Auchmullen, and in the burn below Mid Clova, where the andalusite-schist, especially at the latter locality, is much shattered and contorted, and is also reddened for some distance westwards from the line of fracture. This reddening of the adjacent rocks is apt to give a misleading idea as to the true position of the boundary line, the drift and surface soil often having the characteristic red colour of the Old Red Sandstone area, when schist is actually in place below.

54. Nearly opposite Clova House the fault makes a sudden bend to the east, and at Auchinleith the schists are succeeded by the serpentine

of the Hill of Tombhreac (Towanreef), and this again by diorite, the faulted junction with which is well seen immediately below Craig Castle, in the deep ravine cut by the burn of Craig. The actual line of the fault is generally obscured by drift to the north of this point. At Wheedlemont, however, the uppermost flaggy beds are seen abutting against the serpentine of Cnoc Cailleach, while a well-marked feature, due to the superior durability of the diorite, shows the approximate position of the fault along the base of the Ord Hill. At the farm of Milltown of Noth the Old Red beds are brought against the schists and slates of the Hill of Noth, along whose drift-covered slopes the position of the fault can be only conjecturally determined.

55. On the eastern side of the basin the lowest members of the series rest unconformably on the crystalline rocks, and dipping westwards at moderately low angles, give to the outcrop a more or less sinuous outline. The actual junction is almost everywhere hidden by a thick covering of gravel, but it may be seen in Carlinden Burn, half a mile N.E. from Lumsden, and in the ravine formed by a small burn which falls into the Bogie opposite the Craigs of Tillybrachty. Here the local basement bed, a brecciated conglomerate, rests respectively on slate and granite. At Mosshead, 1½ mile east of Rhynie, the continuity of the boundary line is interrupted by a small cross fault trending N.N.W., which shifts the outcrop of the lower zones and the associated porphyrite about half a mile to the westward.

56. In his paper on the Old Red Sandstone of Western Europe,* the Director-General of the Geological Surveys has separated the sandstones of the Rhynie outlier into six well-marked zones (including the associated porphyrite). Detailed mapping of the ground has shown these zones to be generally persistent throughout the greater part of the basin. They are arranged below in descending order, the local names indicating where the most typical sections are exposed.

(5) Dryden flags and shales.
(4) Quarry Hill sandstones.
(3) Tillybrachty sandstones with volcanic zone.
(2) Lower red shales with calcareous bands.
(1) Basal breccia and conglomerate.

57. (1) The brecciated conglomerate, which forms the local base of the series, is developed as a narrow zone along the eastern margin of the basin, and is nowhere probably more than 50 feet in thickness. It is exposed in the banks of the Don at Milltown of Kildrummy, in the Linthaugh and Carlinden Burns, and other stream sections to the east of Lumsden, and also in the ravine formed by the Slughallan Burn, near Glenbogie. It is a very compact breccia or conglomerate, the fragments small, subangular, and enclosed in a hard, often calcareous, matrix. These mostly consist of quartzite. In the Slughallan section the breccia occurs in bands alternating with very hard, greenish and red calcareous cornstone.

58. (2) In all the sections just mentioned the basement bed is succeeded by the red and purple shales, which form the next division of the series. They are particularly well seen in the Corbiestongue, a deep, narrow ravine S.E. of Glenbogie ; and there consist of red, greenish, and purple sandy shales, with intercalated thin courses of calcareous sandstone, and layers of flattened oval concretions of finely crystalline grey limestone.

* "The Old Red Sandstone of Western Europe" Part I., *Trans Roy. Soc. Edin.*, 1878.

Fish remains were obtained from these limestone nodules by Dr Gordon of Birnie, in 1839.*

59. (3) The Tillybrachty sandstones are so named from the Craigs of Tillybrachty, where they are well exposed in the steep banks overhanging the Bogie, which has here cut a deep, narrow valley through these, the softest members of the series. They are here composed of soft, crumbling, incoherent sandstones, varying in colour from white and pale reddish-grey to deep purple and blood-red. The marked features of this zone are the loose, well-rounded pebbles, which occur at various horizons, either as bands, or scattered irregularly through the sandstone. The bands are often interrupted, forming lenticular nests and layers, and near the base they are sometimes compacted into a semi-conglomerate. Some of these pebbles are of large size. In a good section of these beds, exposed in the ditch between Auchinleith and the burn of Glenny, may be seen rounded quartzite blocks from 1 to 2 feet in diameter. The great majority of the pebbles are composed of quartzite; those of mica and knotted schist are fairly numerous; and granite, gneiss, and felsite fragments, with a few of black slate, also occur. The sandstones are also traversed by thin irregular seams of red clayey shale. In other parts of the basin these beds vary somewhat in character, becoming harder and more flaggy, but always containing the pebbly bands. At one point, however, in a small burn which falls into the Den of Kildrummy at the farm of Dén, they are compacted into a coarse, very hard conglomerate. The junction between this zone and the succeeding Quarry Hill sandstones is not altogether certain in position. Generally obscured by drift, the few places in which it is exposed show a more or less gradual passage from one to the other. The broad general character of each zone is, however, sufficiently distinct, although the choice of the exact horizon at which to draw the line of division may seem to be somewhat arbitrary.

60. (4) The Quarry Hill sandstones take their name from Quarry Hill, one mile south of Rhynie, where they have been long wrought for building stone, and where good sections of the middle and upper beds of the zone are exposed. These consist of thick-bedded white, grey, and pale reddish sandstones, with occasional gritty, or even pebbly, bands. Red clay is very conspicuous at several horizons, forming pipes, circular patches, and branching veins, which traverse the sandstones in all directions. Thin seams of this clay generally separate the thicker beds, and afford beautiful casts and impressions of the often well ripple-marked surfaces.

The Rev. A. Mackay found in these beds in 1854 certain organic remains, one of which is described by Sir Roderick Murchison as "unquestionably a fragment of a large stem of a plant, which measures 4 feet in length by 5 inches in width. It is nearly cylindrical, and is fluted irregularly near the pointed tip. No joints or nodes are visible, as in *Calamites;* but the surface is coarsely striated. The striæ or ribs are too obscure to warrant us in placing this fossil plant in the genus *Columnaria* of Steinberg, which it most resembles." Other impressions occurring on the clay seams were regarded by Hugh Miller as the tracks of crustaceans, while they conveyed to Mr Salter the idea that they might have been made by the pectoral fins of fishes swimming in shallow water.†

The lowest beds are exposed in the burn of Craig, and are there softer

* Malcomson, *Quart. Journ. Geol. Soc.*, vol. xv. p. 350.
† *Quart. Journ. Geol. Soc.*, vol. xv. p. 432.

and more flaggy, with frequent shaly and pebbly bands, and pass gradually down into the Tillybrachty sandstones. At Wester Clova the banks of the Mossat Burn afford good sections of the middle portion of the group, consisting of crumbly white and red sandstones, often much false-bedded and locally crumpled. The rock in the quarries at Broadley and Kildrummy Castle at the southern end of the basin, resembles that of Quarry Hill, but is generally whiter in colour.

61. (5) The highest beds which occur in the basin are the Dryden flags and shales; a series of thin grey flaggy sandstones, alternating with green, grey, and purple micaceous shales. They are exposed at the farm of Dryden and in the Den of Wheedlemont at the back of Quarry Hill; and a good section may be seen in the burn at Castle Hill, 1 mile N.E. from Rhynie.

62. *Structure of the Basin.—Area occupied by the various Zones.*—The general dip of the Old Red Sandstone is to the westward, and the successive zones consequently appear on the Map as longitudinal bands, roughly parallel to the edge of the basin. Between Lumsden and Auchindoir the three highest zones are, however, thrown into an anticlinal fold, the beds dipping away on either side to the north and south of west respectively. This anticline is truncated by the fault as it sweeps round the base of Towaureef Hill, while, owing to denudation, only the lower strata appear in the valley to the east of the burn of Glenny. The Dryden beds give rise to the flat, drift-covered country about Rhynie, and widening to the north occupy the valley of the Bogie to the edge of the sheet. They are cut off by the fault on the west, and do not reappear on the southern side of the anticline.

63. The area occupied by the Quarry Hill sandstone is, from the harder nature of the beds, more diversified in feature; and includes at Quarry Hill (1059 feet) the highest ground in the basin. South of the anticline this zone takes the place of the Dryden beds, as the uppermost division of the series, and lies along the lower slopes of the Clova Hills, the beds dipping westwards at angles of 20° to 30°. Owing to the higher beds having been removed by denudation from the eastern portion of the anticlinal fold, the Tillybrachty sandstones occupy nearly the whole breadth of the basin at Auchindoir, and form the wide stretch of flat, peaty, and alluvial ground to the west and south of Lumsden. The two lowest zones extend as a narrow belt along the eastern limit of the basin, following the contour of the ground, and rising to an average elevation of 800 feet along the flanks of the Correen Hills. These three lower zones thin out rapidly to the north of Glenbogie, so that at the point where they are shifted by the cross fault at Mosshead, the area occupied by the shales and conglomerate is not more than a few yards in breadth, while the Tillybrachty zone is probably represented in great measure by the interbedded porphyrite.

64. *Towie.*—A small detached outlier from this basin lies immediately to the south of the Don at Towie. A bar of conglomerate crosses the river-bed close to the manse, and coarse shaly sandstone can be seen in places beneath the shingle on the northern bank. In the small burn at Cushlachie, below the mill-dam, grey and red sandy shales appear here and there; but beyond this point the red colour of the soil in the fields is the only indication of the extent of ground occupied by the sandstone. The beds seen in the river dip to the N.W. against the gneiss, showing that this outlying patch is also bounded on the west by a fault, a continuation no doubt of that bounding the main basin.

Igneous Rocks in Lower Old Red Sandstone.

(*a*). Interbedded or Contemporaneous.

65. *Diabase-Porphyry.*—Immediately south of the manse of Auchindoir a band of volcanic rock which crosses the valley, was first shown by Mr Geikie to be interbedded with the upper part of the Tillybrachty sandstones, which are seen in the Den of Craig just above. It is probably brought into contact with the serpentine by the bounding fault near Contlach, and thence extends eastwards, crossing the burn near the school. The limits of the bed are, however, conjectural, as the rock is only exposed in one locality, a quarry a quarter of a mile east of the farm of Contlach. Here it is a very compact, hard, fine-grained, bluish-black, diabase-porphyry, representing no doubt the inner portion of the lava flow.

North of Rhynie, and close to the margin of the Map, another band of porphyry occurs between the farms of Boghead and Matnach, and is thrown half a mile to the N.W. by the cross fault of Mosshead. It appears partly to occupy the place of the two lowest zones of the Old Red Sandstone series, and is here a slaggy, amygdaloidal lava. As it is more fully developed in the ground to the north, it will be described at length in the explanation accompanying the adjoining Sheet (86).

(*b*) Intrusive.

66. *Basalt and Dolerite.*—A dyke of hard black dolerite or basalt, having an average breadth of about 12 yards, extends nearly across the Old Red Sandstone basin for more than 1½ mile in an easterly direction between Drumminnor and the mains of Rhynie. It cuts obliquely across the Old Red Sandstone beds, making an angle of between 50° and 60° with their strike, and traverses the zones successively from the lower red shales to the bottom of the Dryden beds. The contact of the sandstone with the basalt is well seen in two or three small openings in the narrow wood west of the home-farm at Drumminnor. In one of these, sandstones with pebbly bands are seen resting against the decomposing basalt; in another more to the west red and purple shales are tilted up at a high, or even overhanging angle against the wall of the dyke. In the farm-steading at the roadside at Drumminnor, the junction of the indurated grey sandstone with the intrusive rock is exposed in ground plan.

Another dolerite dyke occurs at the south end of the basin, extending from the banks of the Don, between Nether Kildrummy and Milltown, for about 600 yards in a south-westerly direction. The dyke has been quarried at both ends for road-metal, and the quarry at the north, close to the river bank, shows the basal conglomerate abutting against the wall of the dyke.

Under the microscope, specimens from the northern dyke at Drumminnor and the mains of Rhynie are found to consist of plagioclase-felspar, augite, and magnetite, with occasional acicular crystals of titaniferous iron. A section from the edge of this dyke shows blades of plagioclase in a microcrystalline ground mass. The rock may, therefore, be regarded as a true dolerite, passing into a basalt at the edge of the dyke.

Specimens from the southern dyke present the same general character, with the addition that a green mineral resembling olivine is present in small quantities.

Nothing can be determined as to the age of these dykes, further than

that they are of later date than the Old Red Sandstone. It is possible that they may form part of the system of basaltic dykes which emanate from the Tertiary volcanic plateau of the Hebrides, and traverse the rocks of the western Highlands.

Drift.

67. Within the limits of this Sheet there are numerous proofs of the intense glaciation to which portions of the country have been subjected. As in former explanations, these proofs are arranged under the following heads—(*a*) Striated Rock Surfaces; (*b*) Boulder-Clay; (*c*) Sands and Gravel; (*d*) Erratic Blocks.

(*a*) Striated Rock Surfaces.

68. The passage of a large body of ice over this portion of the country is proved by the rounded appearance of the hills and striated rock surfaces. When seen from the valley of the Don, a mile or so to the west of Alford, the Correen Hills afford a fine example of the phenomenon of crag and tail. A close examination of the ground has yielded no striæ, the knotted schists being highly unfavourable for their retention on such of these hills as have a north and south trend. The boulder-clay is found at a much higher level on the eastern slopes than on the western, indicating the glaciation to have been from west to east. Between Alford and Deeside the average elevation of the country is much lower, but long, swelling boulder-clay drums with their longer axis running west and east plainly show the general trend of the ice-flow.

When rock-surfaces over the gneiss and schist areas have been long exposed to atmospheric influences they are generally so decayed as to yield but little evidence of striation. At Strone Hill a bed of hard hornblende-gneiss is grooved and striated, and indicates an E. by N. movement of the ice. The bare rock-surface on the top of Pitfichie and Cairnwilliam has been scored with numerous grooves. The direction of these show that the ice of the Don Valley passed E.N.E. over these hills to the low-lying ground beyond. Another portion of the Don ice-sheet passed out of the Alford Valley across the low rock-col at Tillyfourie in a S.E. direction. Good striæ showing the movement are also to be seen on the rock-surfaces at Cluny Quarry.

69. In the northern and eastern portions of the Sheet reliable ice-markings are almost altogether wanting, owing to the rapid decomposition of the igneous rocks of this area when exposed to the atmosphere. At the roadside near Pitcaple Station, however, well-marked striæ may be seen on glaciated quartzite, as well as on polished surfaces of diorite at the edge of Knockollochie Wood a little farther to the west, the striæ indicating in both instances an E.S.E. movement. Less satisfactory striated surfaces of diorite are also found at Pitmachie Wood and on Candle Hill, to the N. and N.W. respectively of Oyne Station.

Owing to the nature of the rocks, and the manner in which they weather, the finer ice-markings are rarely met with in the southern portion of this Sheet. But although the striæ have been effaced by atmospheric agencies, the characteristic *roches moutonnées*, more or less perfectly preserved, still remain. Well-marked striæ running east and west are found on the grit bands of Craigie to the south of Tarland. On the top of the Ord Fundlie and Pitmurchie House Hill there are numerous *moutonnée* and striated rock surfaces. On the west side of the rising ground the striæ indicate a movement of the ice-sheet from west to east, but on the Torphins side of

the hill the direction has changed to E. 20° N. On the Sundayswells Hill of Findrach striæ pointing to S.E. are found on the lower slopes of the hill, these doubtless belong to the later valley glaciation.

(*b*) Boulder-Clay.

70. The boulder-clay presents the usual characters of this deposit, and varies little except in colour throughout the district. Sections in the northern part of the Map show 3 to 4 feet of reddish-brown sandy and earthy clay, which becomes looser and more earthy towards the surface, resting on a stiff greenish or greyish-blue tenacious till. This difference of colour and consistency in the upper portion is due to surface wash and atmospheric action, both varieties being probably part of one and the same deposit.

The clay is usually closely packed with more or less rounded or subangular stones, the finer-grained varieties being well scratched and polished. The majority of the stones are not of large size, but in the valley of the Ury between Inveramsay and Old Meldrum, and again to the west of Rhynie, the clay is filled with huge rounded and subangular boulders of diorite and gabbro, some of which are as much as from 8 to 10 feet in length. These prove a serious evil to the farmers, as they have to be removed from the fields by a laborious process of quarrying and blasting. They are largely used to form the loose dykes which divide the fields, commonly called *consumption dykes*, and which are often several yards in breadth.

The boulder-clay lies thickly over the diorite and gneiss areas to the N. and E. of Bennachie and the Correen range, swathing the lower hills, and thus giving a general smooth and rounded appearance to the features of the country. In the west it is greatly overlaid with gravel, but runs far up on the flanks and into the glens of the Clova Hills and the ranges to the south of the Don. Many of the cols and even smooth summits have a thin covering of stony drift mixed with the natural debris due to weathering.

The contents of the boulder-clay corroborate the evidence given by the glacial striæ for the south-easterly course of the ice-sheet. North of the Ury, about Rayne and Inveramsay, they include many well-scratched fragments of slate and knotted schist from the Foudland Hills which lie to the N.W. Again to the E. and S.E. of the Old Red Sandstone basin, blocks of sandstone occur plentifully in the drift.

71. The boulder-clay of the Alford district is a tough tenacious clay, varying in colour from brown to grey, totally devoid of stratification, and containing subangular stones of all sizes. Only one boulder-clay has been observed in the district, and it appears to be almost entirely derived from the local rocks. The hilltops are generally bare of drift, and the greatest depth of this deposit seems to be to the south of Alford, where it is piled up in large drums and ridges throughout the Sheet. No trace of interglacial sands and gravels has been observed.

The boulder-clay of the Cromar and Midmar districts is generally sandy in its upper part, owing to the large amount of granitic detritus contained in it, but its lower portion is a hard, compact, greenish till full of rounded and subangular boulders of granite, gneiss, and diorite. Most of the hilltops are bare of drift, or else mantled with a thin covering composed of their own detritus.

The burn at Mill of Tornaveen exhibits a typical section of the boulder-clay of this district. It is stiff and sandy, while nine-tenths of the stones are derived from the pink granite of the district, none of them very large.

(*c*) Sands and Gravels (*Kames*).

72. *Kildrummy.*—The most important deposit of gravel in this Sheet occurs in the N.W. between Kildrummy and Rhynie. The area it occupies nearly coincides with that of the Old Red Sandstone basin, its southern limit lying on the northern slope of the Glaschul Hill, whence it extends northwards across the watershed at Lumsden, gradually tailing out, till the last traces are seen a little to the north of Rhynie village. Along the sides of the valley the boundaries of the gravel also nearly correspond with those of the Old Red Sandstone. On the west side the deposit lies considerably higher on the hill-flanks than on the east, rising above the 900 feet contour line along the slopes of the Garlet and Clova Hills; while the greatest height reached on the opposite side about Lumsden does not exceed 750 feet above the sea. In the Kildrummy district the gravel is spread in a thick and tolerably uniform sheet over the country, the fields being strewn with large rounded pebbles of quartzite. Isolated kames occur, however, at the foot of the western hills, as at Truff Hillocks and above Quarryfield. North of the Mossat Burn there is an extensive area occupied by kame-shaped mounds and winding ridges, which reach their maximum development on the watershed, about half a mile north of Lumsden. Here some of the rounded kames reach an elevation of 30 or 40 feet above the general surface of the ground. The longitudinal axes of these mounds trend roughly N. and S., but the winding ridges often unite, and the enclosed basins are filled by small rushy lochans, or when drained, with miniature peat mosses.

73. These kames are composed of alternating beds of sand and gravel of varying degrees of coarseness and well stratified, the dip of the beds generally conforming more or less to the outline of the kame, while the finer sands are often false bedded. The great majority of the pebbles, which are mostly well rounded and waterworn, are composed of white and yellow quartzite, quartzose grit, and vein quartz; next in abundance being those of gneiss, schist, granite, and felsite, which, with various varieties of diorite and gabbro, and a few of limestone and sandstone, complete the list. The great thickness and extent of these gravels, together with the disposition of the kames and ridges, point to their having been deposited at the close of the Glacial Period, when the melting ice, retreating up into the Grampians, sent vast bodies of water down over what is now Upper Strathdon.

74. The entire absence of gravel from the Alford district shows that the water did not then escape, as the ordinary river drainage does now, through the gorge below Invermossat. Being thus diverted almost at right angles to its course above Kildrummy, it must have poured over the watershed into the Bogie Valley, probably escaping to the sea through the drainage basin of the river Deveron. The absence of gravel below Rhynie may be explained by the denuding action of the Water of Bogie, whose alluvial deposits now occupy the ground which was probably at one time covered with a thick sheet of glacial gravel.

Additional evidence as to the source of these gravels is afforded by the materials of which they are composed. The pebbles of white and yellow quartzite, which so greatly preponderate, are no doubt derived from a large area of a similar rock that lies to the west, and forms the higher ridges of the Ladder Hills and the watershed between the Don and Spey. Many fragments also of the coarsely crystalline diorite, peculiar to the dividing ridge between Glen Nochty and Glenbucket, occur, as well as of the crystalline limestone found in Glenbucket and Corgarff, near the head of the Don.

A few isolated kames are also found in the valley of the Gady, on the lower slopes of the Correen Hills, as at Chapelton and Black Hillock in the parish of Leslie. In the valley of the Ury there is an entire absence of gravel deposits, other than the natural river alluvium.

75. *Monymusk and Kemnay.*—On the north side of the Ton Burn a triangular area that extends from Bilboa Bridge to the standing stone of Monymusk is covered with a series of gravel hillocks. On the south side these gravels become regular kames and extend eastwards as far as Kemnay. They are generally composed of coarse gravel, and have boulders of the Green Hill gneiss perched on their tops. From Kemnay to Inverurie irregular sheets of gravel are spread over the surface of the country on both sides of the stream, while smaller mounds occur here and there along the line of railway as far as Kintore. To the south of this village these gravels form sheets and hillocks which occupy both banks of the river, and clothe the slopes for some distance above the highest alluvial terraces. The contents, structure, position, and distribution of these gravels leave little doubt that they are of late glacial age. Between Delab and Red Moss of Coullie are similar kame-shaped gravels.

76. *Midmar.*—A few small gravel mounds lie at the base of Benaquhallie Hill, near Tolmaads. A set of low gravel kames, resting on the top of the local boulder-clay, begins a little above Torphins Station, and extends down the valley to the southern limit of this Sheet, and as far west as Green Burn of Kennerty. A considerable accumulation of similar deposits overlies the low ground to the east of the Hill of Fare. At Garlogie of Echt these glacial deposits consist of large and small hillocks of false-bedded, sharp granitic sand. Some of the mounds that surround the Leuchar Moss have a terraced appearance. The gravel is spread over the sides of the valley for some distance to the north and south of the alluvium of the Leuchar Burn, and extends into the adjoining Sheet (77).. At the base of the Meikle Tap near Howburn, there are some large mounds of this moraine gravel. These gravels surround the peat mosses of Tillyorn and Quartons, and extend along the Gormack Burn as far as Drum Castle. To the east of this point they spread over the low ground, and form part of the gravels of corresponding age and origin which fringe the valley of the Dee. All these gravels are distinctly stratified, and are not moraines in the ordinary sense of the term. Some good sections, exposed on the roadsides near Tillyorn, show this deposit to be a coarse sandy gravel made up of stones of all sizes, a few well striated, together with patches of rudely stratified sand and gravel. From Tillyorn the deposit extends northwards by Redhill till it joins the Leuchar Burn gravels. To the south it forms a great series of mounds, winding ridges, and kames which stretch along the southern limits of this Sheet from Raemoir to Colonach.

77. *Moraines.*—Well-marked moraines occur to the north of Loch Davan, and fringe the steep hill face on its western side. This loch, the former extension of which is marked by the peat flat that stretches for nearly 2 miles to the north-east, is entirely confined by kame-shaped mounds and ridges of moraine gravel, usually well stratified, which form a portion of a considerable spread of the same deposit extending to the south by Dinnet.

(*d*) Erratic Blocks.

78. A study of the erratics scattered over the surface of this Sheet affords further ample proof that the general glaciation of this portion of Scotland has been from west to east. All over the sides and hilltops

of the Cairnwilliam range are found masses and flags of andalusite and knotted schist. As none of these schists occur in place to the east, the evidence at this point is conclusive. The rock of the Green Hill, as has been already noticed, is a peculiar fibrolite gneiss, and from this focus of dispersion boulders are found scattered all over the surface of the country to the south-east between Inverurie and Skene.

Numerous boulders of conglomerate and detached quartzite pebbles from the Old Red Sandstone of Kildrummy cover the western slope of the Callievar Hill, while a lesser number have been carried over its top and deposited in the valley of the Strow Burn. To the south of Callievar and Cairnwilliam numerous boulders of diorite and gabbro form a well-marked stream that has come down the Don Valley from the west of Kildrummy. At the foot of the Langgadlie Hill they are so numerous as to suggest at first sight the possibility that diorite and gabbro is the rock in place below. From this point the boulders are scattered across the country to the east, but rapidly grow less in numbers as they approach the seaboard. Numerous small blocks of an impure serpentine rock, probably from Strathdon, are scattered over the surface of the gneiss ridge between Benaquhallie and the Red Hill. While a few erratics of quartzite, similar in character to that of the hills at the heads of Don, are found on the range to the south of Cushnie.

Fresh-Water Alluvium.

79. Alluvial Sand and Silt.—The centre of the Sheet is occupied by a large triangular area of alluvium 5 miles long by 3 broad. The apex of this flat lies between the Callievar and Manabattock Hills, with its base at the foot of the western slope of Cairnwilliam. Along the northern side flows the Don in a gently winding course, and this plain, together with the rising ground on the south, forms the "Howe of Alford." The alluvial part of the "Howe" overlies a portion of the Alford granite area, and has a mean elevation of 450 feet above sea-level. It does not appear to have been an old lake bottom, but rather to have been occupied by a series of marshes and shallow lochans, as is indicated by the absence of any well-marked marginal terrace. At several points around Meikle Endovie and Mains of Balfluig the boulder-clay drums slope so gently into the gravelly flat that the boundary line which has been drawn is only approximately correct. The south-east corner is now covered by areas of peaty soil, and where the underlying alluvium has been uncovered it is found to be composed to a large extent of granitic debris. This gravel never attains any great thickness, for over this flat portion of the "Howe" the rock in place (granite) is generally found a few feet from the surface. The river with its modern terraces occupies a narrow belt 40 to 50 feet below the general level of the plain, and this, with the narrow valley cut farther to the east of the river Don, between Bennachie and Cairnwilliam, forms a typical example of gorge and plain. A similar case occurs to the east of Monymusk, where the Don after passing through the broad haughlands of Nether Coullie is confined between steep boulder-clay banks from Kemnay to Inverurie.

80. *Inverurie.*—On the Lochter Burn, between Fingask and Mill of Bourtie, and on the Gady to the S.E. of Kirkton of Clatt, considerable areas of flat alluvial land probably occupy the site of former lochs. The haughlands of the Ury widen out below the junction with the Lochter Burn, and reach a breadth of nearly a mile at Inverurie, where the higher terraces are clearly defined. The well-known Bass of Inverurie, situated in the angle between the Ury and the Don, is an isolated fragment

of one of these terraces, but owes its smooth conical outline to human agency. The alluvial deposits of the Don and Ury here join, and are continued to the S.E. of Inverurie till the river leaves the Sheet. In the southern portion of the Map, on the Tarland Burn at Auchlossan, and along the course of the Beltie Burn below Torphins, there are considerable stretches of alluvium. These are in part reclaimed peat mosses, and in the two first-named localities at least, also mark the sites of former lochs. Many of the small streams that fall into the Don in this Sheet have deposited narrow belts of alluvium along their course, and in the case of the Ton and Cluny Burns this alluvium has been subsequently covered by peat. The Kennernie Burn, which falls into the Loch of Skene and its outlet the Leuchar Burn, have laid down considerable alluvial deposits, which in many cases are also covered by peat mosses.

On the south-east side of the Hill of Fare rise the Gormack and Correchie Burns, which have deposited considerable areas of alluvium along their course. In the case of the Correchie Burn the alluvial plain which extends from Mill of Hirm to Rusheulochy marks the site of what was once a shallow loch. A small portion of its drained surface is occupied by peat, but the greater portion is now reclaimed and under cultivation. Its south-east and north-east side are well marked, as they are encircled by sloping banks from 20 to 50 feet high.

81. Peat.—Peat is generally distributed all over this Sheet, but with a few exceptions the mosses do not cover large areas. The mosses of Essie and Tonburn on the western edge of the Sheet in the parish of Rhynie, with the moss on the Clova estate immediately to the west of Lumsden village, are the only peat deposits of any extent in the northern part of the Map. About Kennethmont and Clatt there are several smaller mosses, now mostly exhausted; and there is also a considerable thickness of hill peat on the flat summits and cols of the Clova Hills.

The mosses to the south-east of the "Howe" of Alford are small and nearly exhausted; those in the hollows of the Correen Hills are in a similar condition. In the eastern division of this Sheet the Red Moss of Coullie is the largest; those of Firley and Lauchintilly are partially exhausted, while the Banshed Moss is completely dug out. Around the Loch of Skene are several peat mosses of considerable extent, the largest being those of Skene, Castle Fraser, and Moss of Air.

There are several large patches of peat in the low ground which sweeps out from the south-eastern base of the Hill of Fare. The largest of these lies between the Bank of Finarey and Druggam, and covers about a square mile and a half. Another peat moss has already been referred to as marking the former extension of the Loch of Davan.

Diatomaceous Deposits.

82. At several localities in the district represented on the present Map, underneath the peat a deposit of what is known as "white peat," diatomite, or diatomaceous earth is found. Between the manse of Logie Coldstone and Dinnet, at the foot of Morven and Culblean Hill, lies a large extent of flat, peaty, and alluvial land, formerly no doubt occupied by a lake or chain of lakes, of which Lochs Davan and Kinnord and the smaller pools about Coldstone, are the remains. In this area large quantities of "white peat" have been found at varying depths beneath the brown peat covering. This substance forms a greyish fibrous mass, very porous, and composed of 25 per cent. of vegetable matter, with 65 per cent. of siliceous diatomaceous earth, the *Kieselguhr* of the Germans. The following table shows the localities, area, cubical contents, and thick-

ness (where known), with the average depth below the surface of the various deposits of diatomite:—

Locality.	Area.	Mean Thickness.	Approximate Cubic Contents.	Depth Below Surface.
Blackmoss.	162 acres (about).	15 ft. to a few ins.	800,000 yards.	1–6 feet.
Ordie Moss.	Originally 8 acres, now exhausted.			
Loch Kinnord.	In great part under water.	Has not been measured.		
Haugh of Milton.	10–12 acres.	1 foot.	17,700 yards.	2½ feet.
Auchnarran.	46 acres.	15 inches.	92,700 yards.	2½ feet.

For the sake of convenience these deposits are here described as a whole, although only two of them, the Blackmoss and Ordie Moss, lie entirely within this Map; Loch Kinnord coming into the Sheet to the south, while the greater part of Milton and Auchnarran are included in Sheet 75 to the west. The Blackmoss and Ordie Moss areas have been worked for some few years, the diatomite being largely used in the manufacture of dynamite, artificial ultramarine, siliceous paints, &c. At present the demand is not large. In the year 1885, 200 tons only were disposed of from each of these two deposits. It is calculated that 6 cubic yards of the raw material, when dried, yield 1 ton of *Kieselguhr*. In the appendix will be found a list of the diatomaceæ collected from these deposits by the Rev. Geo. Davidson, LL.D., minister of Logie Coldstone, to whose courtesy also much of the above information is due.

Diatomite was also obtained from peat mosses near Premnay about the year 1848.

Economic Minerals.

83. *Building Materials.*—The chief stone used for building purposes in this Sheet is granite. The largest quarries are situated at Kemnay, Tillyfourie, and Hill of Fare, while smaller ones are wrought at Mountgarrie, Craigear, Sille-Hill, &c. With the exception of the Cluny and Hill of Fare quarries, which produce a red granite, all the above mentioned are wrought in grey. Quarries have been opened in the Bennachie rock from which large blocks were cut and used in the construction of the Sheerness docks, but these had to be abandoned on account of the depth of decomposed rock that required to be removed.

The andalusite-schists of the Correen Hills were at one time extensively wrought to supply a local demand for flagstones. Some of the finer and more fissile bands were at the same time used for roofing purposes instead of slate. The chief quarries are situated at Correen and Gallows Top, but these have been abandoned for a considerable number of years.

The Old Red Sandstone affords the only freestone in the district, and is largely wrought at Quarry Hill, near Rhynie. It affords an excellent building stone, working freely in all directions, and is much used for lintels, corner stones, and the finer class of dressed work. At Quarryfield in Kildrummy, a very white variety of this sandstone is wrought into gravestones. The "Snow Tower" of Kildrummy Castle, so called from its extreme whiteness, was built from a quarry in the same rock.

Grey slates have been worked at the Carlinden Quarry and at Whitely, near Lumsden, but they are thick and heavy, and of inferior character for roofing purposes.

The field-walls or dykes are usually built from small quarries opened in the adjoining fields, any rock that is at hand being used indifferently; many, however, are simply formed of the large stones derived from the boulder-clay.

84. *Road Materials.*—The finer varieties of gneiss and the more hornblendic diorites are much employed for road metal; but felsite, porphyry, and the finer-grained granites are used in preference where they can be obtained. In drift-covered districts recourse is largely had to the stones which strew the fields, and a stone heap by the roadside is often a miniature museum of petrology.

In the Alford district stones from the neighbouring fields or from quarries opened in the harder schist-bands afford the chief supply of road metal. In the vicinity of the granite quarries this rock is used, but it does not make a lasting road. Over the south-east portion of the Map it is the only rock available. The gneissose variety of granite is generally preferred.

85. *Limestone.*—This rock is very sparingly developed in the districts contained in this Sheet, and the bands that have been wrought are all associated with the metamorphic series. One good calcareous schist has been quarried on the Limer Shank of the Correen Hills, and a dolomitic band has been worked at Loanend in the parish of Leslie.

86. *Ores.*—On Pitfichie Hill a small drift has been cut for a short distance through a reef of quartz containing hæmatite, but as the ore was not present in sufficient quantities the working was abandoned after a short trial. At Sylavethy oxide of copper is found in sparing quantities disseminated through the granite. On the Brinny Hill sometimes fine specimens of amethystine quartz have been obtained from a quarry on its southern slope.

87. *Fuel.*—The only kind of fuel that can be obtained within the limits of the Sheet is peat, but many of the mosses are being rapidly exhausted.

Soils.

88. Where there is any extent of ground under cultivation, the soil of the bottom lands in the Don Valley generally consists of a good loam. Sometimes a portion of this is rendered of less agricultural value by a covering of peaty soil. The hill slopes on both sides of this valley are covered with a cold retentive boulder-clay often of no great depth. The moorland and hills that form the watershed to the north and south of the Don have but little soil upon them, and are generally more or less covered with a stony earth composed of the detritus of the rocks beneath. Between Cluny and Skene the soil is a fairly strong clay, to a large extent derived from the decomposed granite which is in place below. Alongside the small stream that drains into the Loch of Skene peat often occurs, which mixed with the stiff clay forms a fair loam. The eastern portion of the Garioch that lies between Inverurie and Bennachie is covered with some of the best soil in this district. It is generally a stiff clay, which is often rendered less heavy by an admixture of granite detritus carried by the surface water from the bare rock slopes above. The diorite area to the north of Bennachie is overlain by a stiff stony boulder-clay becoming thin and poor along the top of the ridge. The gravel-covered country between Kildrummy and Lumsden village contains some of the best corn-producing land in the district. Beyond this fertile tract rises the bare moorland ridge of the Clova Hills, the cultivated land partly extending beyond the Old Red Sandstone basin.

APPENDIX.

I. LIST OF ROCKS FROM THE GROUND INCLUDED IN SHEET 76, MICROSCOPICALLY EXAMINED BY J. J. H. TEALL AND F. H. HATCH, PH.D., AND OF WHICH A DESCRIPTION WILL BE FOUND IN THE TEXT.

Species of Rock.	*Locality.*
Limestone,	Wood Head, near Banchory.
,,	Bridge of Feugh.
Garnetiferous quartzite,	West of Pitcaple Station.
Altered grit,	Mullach Hill, 1 mile N.N.E. of Dinnet.
Hydro-mica schist,	Upper Edingarioch, Leslie.
Mica schist,	Whiteley.
,,	Milton of Kildrummy.
Knotted and andalusite schist,	Correen Quarry, 6 miles N.W. of Alford
,, ,,	River Don, opposite Macharshaugh.
,, ,,	North Strone, S. of Alford.
Chiastolite schist,	Invermossat.
Gneiss,	Clayhooter Hill, Rhynie.
,,	Hillbrae, foot of Bennachie.
,,	Gunhill, Inveramsay.
,,	Cluny Quarry, Tillyfourie.
,,	No. 3 Quarry, Tillyfourie.
Cordierite or fibrolite gneiss,	Kist Hill, E. of Alford.
,, ,,	North Strone, Alford.
Biotite-muscovite-gneiss,	Tornaveen.
,, ,,	Above Braehead, Craiglich Hill.
,, ,,	Craigenhigh, N.N.E. of Tulloch Venus.
,, ,,	Lofthillock, E. of Inverurie.
,, ,,	Greatstone, W. of Kemnay.
Biotite-gneiss,	Queen's Hill, N. of Aboyne.
,,	Hill above Desswood.
,,	Hill above Wester Kincardine.
,,	Clash, 2 miles N. of Lumphanan.
,,	Wester Kincraigie, Lumphanan.
,,	Chapel, 1 mile E. of Corse Castle.
,,	Roadside, Corse Castle.
,,	Beltie Hill, S.E. of Torphins.
,,	Railway, ¼ mile W. of Glassel Station.
,,	Rinnalloch, 4 miles N.E. of Lumphanan
Granite-gneiss,	Crichie, 1 mile S. of Inverurie.
,,	Tillyfourie Quarry.
Granite,	Clovenstone, Kintore.
,,	Keith Hall, Inverurie.
,,	Kemnay Quarries.
,,	Finarey, E. of Echt.
,,	Cairnwilliam.
,,	Near F.C. Manse, Alford.
,,	Craigmyle, Torphins.
Biotite-granite,	Tornaveen Hill.
Muscovite-granite,	Mineu, 2 miles W. of Torphins.

Species of Rock.	*Locality.*
Granite vein in fibrolite-gneiss, .	Kist Hill, Alford.
Hornblende-granite, . . .	Sylavethy Quarry, Alford.
Mica trap, ...	Kemnay Quarries.
Syenite, ...	Dunnideer Hill, Insch.
„	Newbigging, N.W. of Clatt.
Labradorite-rock, . . .	New Seat, Leslie.
Augite-diorite, . . .	Hill of Johnstone, Insch.
Quartz-mica-diorite, . . .	Railway, 1½ mile W. of Torphins.
„ . .	Hindrum, S. of Torphins.
„ . .	Quarry, ⅛ mile N.N.E. of Torphins.
Mica-diorite, . . .	Dual Wood, Rhynie.
„	Creak, W. of Rhynie.
„	Dess Burn, near Dess Station.
Tonalite, . .	Hillhead, 2 miles S. of Lumphanan.
Gabbro-diorite, . .	Footie, S. of Torphins.
„	Outfield of Tarland.
„	Whistlebare Hillock, N.N.W. of Tarland.
„	Wester Migvie, Tarland.
Schistose amphibolite, .	Burn of Old Mill, N. of Tarland.
„ . . .	Burn of Glenny, Rhynie.
Hornblende schist, . .	Redwell, 1½ mile S. of Tillyfourie.
„ .	E. of Cairnhill, Tillyfourie.
Olivine-gabbro, . .	Barra Castle, Old Meldrum.
„ . . .	Railway cutting, Pitcaple.
Serpentine, . .	Camp, Barra Hill.
Diabase-porphyry, .	W. of Auchindoir, Rhynie.
Basalt and dolerite, .	Druminnor.
„ . . .	Mains of Rhynie.
„ . .	Milltown of Kildrummy.

II. LISTS OF FOSSILS.

Lower Old Red Sandstone.

Crustacea.—Pterygotus (portion of gnathite palpus). Quarryfield, Kildrummy.
Tracks of burrowing crustacean or annelid. Quarryfield, Kildrummy.
Obscure Plant-remains abundant at Quarry Hill, Rhynie.

III. LIST OF DIATOMACEÆ FOUND IN DIATOMITE FROM LOCH KINNORD.

Freshwater Alluvium.

By the Rev. Geo. Davidson, LL.D. (*Minister of Logie-Coldstone*).

(Taken from a paper read before the Edinburgh Geological Society in April 1882. By W. Ivison Macadam, F.C.S.)

Epithemia turgida, Ktz.
„ gibba, Ktz.
„ sorex, Ktz.
„ Zebra, Ehr.
„ ocellata, Ktz.
„ gibberula, Ktz.
„ Alpestris, Ktz.
„ ventricosa, Ktz.
„ Hyndmanii, Smith.
„ granulata, Ktz.
„ proboscidea, Ktz.
„ globifera, Heiberg.

Eunotia Arcus, var. incisa, Ehr.
„ uncinata, Ehr.
„ gracilis, Sm.
„ major, Sm.
„ impressa, var. minor, Grunow.
„ Formica.
„ nodosa, Ehr.
„ pectinalis, Dillw.
„ undulata, Sm.
„ tetraodon, Ehr.
„ ventricosa.
„ bigibba, Greg.

Eunotia Diadema, Ehr.
„ Camelus, Ehr.
„ monodon, Ehr.
„ Faba, Ehr.
„ lunaris, Breb.
„ triodon, Ehr.
„ Sp. (?).
Cymbella Ehrenbergii, Ktz.
„ cuspidata, Ktz.
„ Scotica.
„ hercynica, Schmidt Atlas, ix. 30, 31.
„ Pisciculus, Greg.
„ turgida, Greg.
„ naviculiformis, Amd.
„ Sp. (?), Atlas, ix. 56.
„ obtusiuscula, Ktz.
„ angustata, Grun.
„ Norwegica, Grun.
„ acutiuscula, Grun.
„ æqualis, Sm.
„ (Navicula) Cesatii (Rhab.).
„ anglica, Lagerst.
Amphora ovalis, Ktz.
„ lineata.
Cocconeis Placentula, Ehr.
„ Helvetica, Brun.
Achnanthidium flexellum, Breb.
„ lanceolatum, Breb.
„ Jackii (?).
Cyclotella operculata, Ktz.
„ rotula, Ktz.
„ Kutzingiana, Thw.
„ papillosa, O'Meara.
„ antiqua, Sm.
Surirella nobilis, Sm.
„ splendida, Ktz.
„ linearis, Sm.
„ tenera, Greg.
„ constricta, Ehr.
„ Craticula, Ehr.
Tryblionella angustata, Sm.
Cymatopleura apiculata, Pritch.
„ elliptica, Breb.
Nitzschia angustata, Grun.
„ Denticula, Grun.
„ linearis, Sm.
„ Sigmoidea, Sm.
„ parvula, Sm.
Navicula divergens and vars., Sm.
„ acuta, Kg.
„ nodosa, Ehr.
„ stauroptera, Grun.
„ gibba, Ktz.
„ viridula, Ehr.
„ firma, Ktz. and Grun.
„ hebes, Ralp.
„ mesotyla, Ehr.
„ lævissima, Grun.
„ Sp. (?), Atlas of Diat., 44, 51.
„ nobilis, Ktz.
„ follis, Ehr.
„ Rhomboides, Ehr.
„ Amphioxys, Ehr.

Navicula major, Ktz.
„ Mormonorum, Atlas, 44, 24.
„ dicephala, Ehr.
„ var. Stauroneiformis.
„ Brebissonii, Rabh.
„ viridula, var. major.
„ rupestris, Grun.
„ Iridis, Ehr.
„ viridis, Ktz.
„ interrupta, Ktz.
„ cuspidata, Ktz.
„ angustata, Sm.
„ ovalis, Sm.
„ Americana, Ehr.
„ cocconeiformis, Greg.
„ Sorians, Kg.
„ affinis, Ehr.
„ borealis, Ehr.
„ limosa, Grun.
„ radiosa, Rabh.
„ cardinalis, Ehr.
„ divergens, var. Mullensis, Greg.
„ semicruciata, Ehr.
„ gracillima, Pritch.
„ polyonca, Breb.
„ amphigomphus, var., Atlas, 49.
„ fulva, Ehr.
„ punctata, Ehr.
„ Sp. (?), Atlas, 44, 51.
„ Bacillum, Ehr.
„ Stauroptera, var., Grun.
„ Sp. (?), Atlas, 43, 25.
„ pygmœa, Ktz.
„ Scutelloides, Sm.
„ tumida, Sm.
„ acrosphœria, Breb.
„ Hitchcockii, Ehr.
„ Braunii, Grun.
„ inflata, Ktz.
„ leptogongyla, Ehr.
„ Sp. (?), Atlas, 45, 28.
„ Sphœrophora, Ktz.
„ termitina, Schmidt.
„ commutata, Schmidt.
„ crassinervia, Breb.
„ exilis, Grun.
„ rhyncocephala, Ktz.
„ lacustris, var., B. Greg.
„ oculata, Breb.
„ mesolepta, Ehr.
„ amphirhynchus, Ehr.
„ Zellensis, Grun.
„ Serians, var. minor.
„ hemiptera, Ktz.
„ undulata, Greg.
„ nodulosa, Grun.
„ Stomatophora, Grun.
„ rhombica, Greg.
Stauroneis Phœnicenteron, Ehr.
„ anceps, Ehr.
„ dubia, Greg.
„ acuta, Sm.

Stauroneis linearis, Ehr.
Pleurosigma attenuatum, Sm.
„ lacustre, Sm.
„ Spencerii, Sm.
Synedra ulna, Ehr.
„ biceps, Kg.
„ capitata, Ehr.
„ lunaris, Ehr.
„ radians, Kg.
„ linearis, Sm.
„ longissima, Sm.
„ acus, var. tenuissima, Kg.
Cocconema lanceolatum, Ehr.
„ cymbiforme, Ehr.
„ cistula, Hemp.
„ parvum, Sm.
„ Helveticum, Grun.
Gomphonema acuminatum, Ehr.
„ insigne, Greg.
„ dichotomum, Ktz.
„ constrictum, Ehr.
„ subtile, Ehr.
„ vibrio, Ehr.
„ Hebridense, Greg.
„ Brebissonii, Grun.
„ intricatum, Kg.
Gomphonema turris, Ehr.
„ geminatum, Ag.
„ Cygnus, Ehr.
„ tenellum, Kg.
„ elongatum, Grun.
Fragilaria capucina, Desm.
„ lapponica, Grun.
„ virescens, Ralfs.
„ var. exigua, Grun.
„ construens, Grun.
„ undata, Sm.
Tabellaria fenestrata, Lyngb.
Stenopterobia anceps, Grun.
Encyonema gracile, Rab.
„ Lunula, Grun.
„ cæspitosum, Kg.
Denticula tenuis, Kg.
„ inflata, Sm.
Tetracyclus lacustris, Ralfs.
Melosira crenulata, Thw.
Stephanodiscus minutulus, Grun.
Campylodiscus noricus, Ehr.
Odontidium mutabile, Sm.
Mastogloia Grevillei, Sm.
Ceratoneis Arcus, Kg.

Of these species, *Cyclotella antiqua* is the only one not now found living in the loch.

IV. LIST OF PUBLICATIONS RELATING TO THE GEOLOGY AND PALÆONTOLOGY OF THE DISTRICT INCLUDED IN SHEET 76 OF THE GEOLOGICAL SURVEY OF SCOTLAND.

1840. Geological Map of Scotland. Dr J. Macculloch, F.R.S.
1850. "Notice of Fossil Diatomaceæ found in Aberdeenshire," by Prof. G. Dickie. *Proc. Bot. Soc. Edin.*, vol. iii. p. 65.
1859. "Notice of a Deposit of Diatomaceæ," by Prof. Dickie. *Mag. Nat. Hist.*, 2nd series, vol. ii. p. 93.
1859. "On the Relations of the Different Parts of the Old Red Sandstone in the Counties of Moray, Nairn, Banff, and Inverness," by J. G. Malcomson, M.D., F.R.S. *Quart. Journ. Geol. Soc.*, vol. xv. p. 350.
1859. "The Sandstones of Morayshire, and their relations to the Old Red Sandstones of that County," by Sir Rod. J. Murchison, F.R.S. *Quart. Journ. Geol. Soc.*, vol. xv. p. 432.
1860. "On the Geological Structure of the Vicinity of Aberdeen and the North-East of Scotland," by Prof. James Nicol. *Brit. Assoc. Rep.*, 1859, and *Edin. New. Philos. Journal*, New Ser., vol. xi. p. 126.
1865. "On the Drift and Rolled Gravel of the North of Scotland," by T. F. Jamieson, LL.D. *Quart. Journ. Geol. Soc.*, vol. xvi. p. 347.
1866. "Geology of the North of Scotland," by Prof. Nichol.
1878. "The Old Red Sandstone of Western Europe," by Arch. Geikie, LL.D., F.R.S. *Trans. Roy. Soc. of Edin.*, vol. xxviii. p. 345.
1882. "On the Analysis of a Sample of a White Deposit from the Peat of Aberdeenshire," by W. Ivison Macadam, F.C.S. *Trans. Edin. Geol. Soc.*, vol. iv.
1883. "On the Results of the Analysis of Diatomaceous Deposits from the Peat of Kinnord, Ordie, Drum, and Black Moss, Aberdeenshire," by W. Ivison Macadam. *Trans. Edin. Geol. Soc.*

1884. "On Diatomaceous Deposits in Scotland," by W. Ivison Macadam. *Mineralogical Mag.*, June 1884.
1885. "On certain Diatomaceous Deposits (Diatomite) from the Peat of Aberdeenshire," by W. Ivison Macadam. *Brit. Assoc. Rep.*, 1885.
1885. "Bastite-Serpentine and Troktolite in Aberdeenshire," by Prof. Bonney, LL.D., F.R S. *Brit. Assoc. Rep.*, Aberdeen, 1885.
1885. "The Bass of Inverurie ; a fragment of an ancient Alluvial Bed," by Rev. John Davidson, D.D. *Brit. Assoc. Rep.*, 1885.

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